Chemical &
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NEWS
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Du Pont's Irving S. Shapiro
wins SCI Medal Page 13

PLANT CAPACITY USE

[illegible] high for basic chemicals and polymers Page 11

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Chemical & Engineering NEWS

Cover: Chemical society presidents at ACS headquarters, Washington, D.C. (See page 45 for identities.) Photo by Barry Baron/Photo Optik

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News of the Week

- ***Uniform federal cancer policy*** *contains few surprises, gets mixed reaction—from disappointment to half-hearted support—from industry groups.* **Page 6**
- ***American Association of Engineering Societies*** *organized to replace Engineers Joint Council; will act as spokesman for the engineering community.* **Page 6**
- ***Du Pont data*** *on inventory correction process for synthetic fibers, based on cycles of retail buying, indicate fibers may weather the recession fairly well.* **Page 7**
- ***The Hoechst Group will spend $171 million,*** *15% of total capital outlays, in 1980 on its U.S. operations, says chairman of firm's board of management.* **Page 7**
- ***Two new biological controls*** *for agricultural products, bacterium to prevent insect damage to stored grain and pheromone for navel orangeworm.* **Page 8**
- ***Further study*** *of federal coal-leasing policy, regional air pollution loading, and production of synthetic fuels from coal recommended by coal policy project.* **Page 8**

Business

- ***Plant capacity use continues high*** *for a number of important chemicals and polymers. Average plant use in the third quarter in plastics and fibers hit 91% of effective top level.* **Page 11**
- ***Irving S. Shapiro,*** *chairman of Du Pont, has received the Chemical Industry Medal of the Society of Chemical Industry's American Section.* **Page 13**

Government

- ***Federal funding of R&D will be up*** *for fiscal 1980; NIH, NSF, and NASA got good budget increases, although about 1% less than Administration requests.* **Page 16**

Technology

- ***Continuous process for hydrolysis*** *of cellulose to glucose has been achieved using a twin-screw extruder and a high-temperature sulfuric acid process.* **Page 19**
- ***Diethylhydroxylamine,*** *a free radical scavenger that is oxidized in the atmosphere, is considered the best choice for chemical control of photochemical smog.* **Page 20**
- ***Laser light photometer*** *is developed for molecular weight determination with gel permeation chromatography.* **Page 22**
- ***Boiler monitoring system*** *uses carbon monoxide concentration to measure maximum thermal efficiency; produces fuel savings of 2 to 5% in boilers.* **Page 22**

Books

- ***Two books about the origin of life,*** *"Genesis on Planet Earth" and "Lifecloud," are as far apart as Archean Earth and interstellar gas clouds.* **Page 29**

ACS News

- ***Nominations for ACS awards,*** *to be presented in 1981, are being solicited now; nominations must be postmarked no later than midnight March 1, 1980.* **Page 34**

Chemical plants running near full capacity

Production of some chemicals stretched capacity limits in the third quarter, but overall capacity use differs little from the first quarter

The third quarter of 1979 was a good time to measure use of plant capacity in the U.S. basic chemical industry. For a number of important chemicals and polymers, whatever plants put out was the most that they could. Hence, this summer calibrated the effective maximum volume for a number of chemical businesses, barring further investment.

The general level of capacity use in the third quarter still did not come up to 1974, when the chemical economy was in a similarly exuberant state just before the recession hit. But a toned-down version of 1974 is probably what the industry has gone through this year. With a special boost from exports, chemical demand is up over 1978, leading to product price increases and generally improved profits for many chemical companies.

In C&EN's semiannual survey of 28 leading basic chemicals, average nameplate capacity use in the third quarter was 79%. Effective capacity use was 89%.

These figures are well up from capacity use a year ago, which was 75% of nameplate and 82% of effective maximums. However, the most recent percentages are roughly the same as the corresponding 80% and 90% in the first quarter of 1979.

For the industry's basic polymers, the large-volume thermoplastics and synthetic fibers—included in the survey for the first time—capacity use is running even higher. In the third quarter, average plant use in plastics and fibers hit 84% of nameplate and 91% of effective top levels. A year ago, the averages were 80% and 86%.

Within the broad averages this year, performance varied considerably for individual products. Under intense demand pressure, some products ran up to or beyond annual effective maximum output rates. Listing these products makes a good rundown of the hottest chemical and polymer markets—butadiene, soda ash, phosphoric acid, vinyl chloride, low-density polyethylene, high-density polyethylene, and polyvinyl chloride.

Plants can always exceed annual effective maximum output rates as long as maintenance is delayed and a few other corners are cut. But eventually, these lofty marks will have to come down. If the apparent recession now under way in the U.S. deepens in the next six months, a breather may take hold.

Besides the products in obviously tight supply, a number of others are in the same practical market state, although their capacity use is lower. The reason is feedstock scarcity or substitution.

For example, propylene, especially polymer grade, has been in much

Some capacity use in polymers stretches limits

	Third-quarter 1979			Third-quarter 1978		
	Capacity name-plate	Capacity use		Capacity name-plate	Capacity use	
Billions of lb		Name-plate	Effective		Name-plate	Effective
Plastics						
Polyethylene, low-density	8.5	92%	99%	8.1	90%	97%
Polyvinyl chloride	7.1	87	101	6.8	84	98
Polyethylene, high-density	5.5	95	100	5.0	34	88
Polystyrene	5.3	74	86	5.2	69	77
Polypropylene	5.0	80	89	4.2	69	77
Synthetic fibers						
Filament yarn						
Polyester	2.1	78	83	2:1	74	79
Nylon	2.0	85	90	1.9	87	93
Olefin	0.94	66	70	0.93	87	71
Staple						
Polyester	2.6	92	98	2.6	82	87
Nylon	1.0	91	97	0.95	98	104
Acrylic	0.85	84	89	0.87	72	77
AVERAGE		**84%**	**91%**		**80%**	**86%**

Sources: Industry sources, Textile Economics Bureau, C&EN estimates

C&EN's capacity use indicator—the ground rules

Capacity use at chemical plants is difficult to measure and requires certain assumptions to bring some order to the maze of variables affecting this critical indicator of the industry's health.

With the help of industry and government sources, C&EN measures capacity use as a percentage of both nameplate and effective maximums. Nameplate capacity is the official design capacity of plants at nonstop use all year. Effective capacity is the practical maximum capacity after reductions for regular maintenance shutdowns and changes in product mix. Effective capacity runs from 85 to 95% of nameplate for most chemicals.

Capacity use is given semiannually over a calendar quarter with no seasonal adjustment. The figures include plants actually running. Figures exclude new plants just starting up and old plants knocked out for long periods by accidents or mothballing. As much as possible, capacity figures stay current with expansions and debottlenecking.

Capacity figures do not take into account temporary fluctuations for fuel and electric power interruptions, equipment failure, and feedstock scarcity or substitution. The feedstock variables have been especially important in 1979, further reducing maximum output for a number of important products.

Products in C&EN's capacity use survey are the same as those in the Key Chemicals and Key Polymers series. These are the core products of the industry, the basis for downstream production of thousands of more specialized products. □

Some effective capacity use hits 100%

Billions of lb per year unless otherwise noted[a]	Third-quarter 1979			Third-quarter 1978		
	Capacity	Capacity use		Capacity	Capacity use	
	name-plate	Name-plate	Effective	name-plate	Name-plate	Effective
Oil-based petrochemicals						
Ethylene	36.5	89%	99%	32.5	80%	89%
Propylene (chemical)	20.5	72	80	19.0	68	76
Butadiene[b]	4.0	90	100	4.3	82	91
Benzene (bg)	2.3	77	84	2.2	67	74
***p*-Xylene**	5.7	79	88	4.3	71	79
Natural gas-based petrochemicals						
Methanol (bg)	1.4	85	94	1.4	71	79
Formaldehyde (37% solution)	9.1	74	78	8.7	74	78
Ammonia (mt)	20.4	91	96	19.0	88	93
Urea (mt)	7.5	87	97	6.2	82	91
Chlor-alkalies						
Chlorine (mt)	14.4	88	93	13.9	81	85
Caustic soda (mt)	15.1	85	90	14.6	77	81
Soda ash (mt)	8.8	95	100	9.8	83	87
Acids						
Sulfuric (mt)	56.0	81	85	55.5	67	71
Phosphoric (P_2O_5, mt)	9.8	94	99	9.8	88	93
Industrial gases						
Oxygen / **Nitrogen** (total, liquid, ttd)	31.2	67	83	31.5	57	84
Carbon dioxide (ttd)	12.5	52	62	15.7	51	60
Mineral-based inorganics						
Sulfur (Frasch, mlt)	6.7	96	—	7.6	77	—
Phosphorus (mt)	0.55	78	85	0.57	82	86
Plastics monomers						
Styrene	8.4	89	94	8.7	80	84
Vinyl chloride	8.4	99	109	8.8	71	79
Propylene oxide	3.0	83	92	3.0	67	74
Fiber monomers						
DMT/PTA[c]	7.3	68	80	6.6	72	85
Ethylene oxide	6.5	78	82	5.9	80	84
Cyclohexane	3.2	78	83	3.2	63	66
Adhesives and coatings monomers						
Phenol	3.5	80	89	3.5	75	81
Vinyl acetate	2.4	83	87	2.1	81	85
Pigments						
Carbon black	4.3	73	85	4.0	83	91
Titanium dioxide (mt)	0.88	88	98	0.94	80	89
AVERAGE		**79%**	**89%**		**75%**	**82%**

[a] bg = billions of gal, mt = millions of tons, ttd = thousands of tons per day, mlt = millions of long tons, mg = millions of gal. [b] Based on extraction capacity of steam-cracking plants and dehydrogenation capacity only of dehydrogenation producers; could be more if extraction capacity of dehydrogenation plants were included. [c] Dimethyl terephthalate plus purified terephthalic acid, not including acid converted to DMT. **Sources**: Industry sources, C&EN estimates

tighter supply than indicated by its nameplate capacity use of 72%. This important building block chemical has been hit both by scarcity at oil refinery sources and by feedstock substitution at olefins plants.

A feedstock pinch also has been important in holding down capacity use in benzene, even more in demand than propylene for alternate gasoline use as an octane booster. To a lesser degree, urea has been squeezed by a shortage of raw material carbon dioxide due to shutdown of a number of ammonia plants, which coproduce the material. Still, urea is considered a tight product and an export item in great demand.

Because industry executives are divided on whether and how much the chemical industry could feel a recession, a downturn for capacity use caused by market instead of feedstock factors is not yet certain. However, the lack of further gains overall since the first quarter suggests that the big rise in capacity use a year ago has stalled.

Bruce Greek, C&EN Houston, and William Fallwell, C&EN New York

CHECKOFF

MERGERS

- **Cook Paint & Varnish**—Completes tender offer for all outstanding shares of its stock at $36.25 per share, thus clearing way for merger into BASF of West Germany

- **Ciba-Geigy** — Purchases Louisiana Seed Co. of Alexandria, La., for undisclosed amount. Acquisition of seed firm will expand Ciba-Geigy's Funk Seeds operations from 21 to 28 states.

- **W. R. Grace**—Acquires J. B. Robinson Jewelers, Cleveland-based chain of 47 jewelry stores throughout Midwest. Merger was completed for undisclosed amount of stock.

- **B. F. Goodrich**—Completes tender offer for Tremco Inc. common stock at $40 per share. At expiration of tender offer, more than 82% of Tremco shares had been received or guaranteed. Under merger terms, Tremco will become wholly owned subsidiary of Goodrich.

- **National Distillers & Chemical**—Sells Monterey, Calif., FM radio station owned by subsidiary A-B Chemical to Buckley Broadcasting Corp. of Monterey, for $700,000.

- **Tyco Laboratories**—Acquires Armin Corp., New Jersey-based manufacturer of plastic film and film products. Armin stockholders will receive $16 per share in cash, making value of deal about $27 million.

NEW PLANTS

- **Hydrogen peroxide**—FMC plans to complete expansion for high-purity hydrogen peroxide this fall at Vancouver, Wash. Capacity will be doubled to unspecified level.

- **Styrene-butadiene elastomers**—Arco Polymers subsidiary of Atlantic Richfield plans to enter field of styrene-butadiene-based thermoplastic elastomers with construction of semicommercial facility of unspecified size next to existing operations in Monaca, Pa. Unit is scheduled to come on stream in early 1980.

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Stratospheric ozone loss

The question is being raised again

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Cover: Predawn launch of balloon to take stratospheric samples for total chlorine analysis. Photo courtesy of Walter W. Berg, National Center for Atmospheric Research, Boulder, Colo.

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News of the Week

- ***Genes have been injected into mouse cells*** *using microsurgical methods; experiments could pave way to curing inborn errors of human metabolism.* ***Page 6***
- ***NSF deputy director George Pimentel*** *will succeed Melvin Calvin as director of LBL's Laboratory of Chemical Biodynamics upon Calvin's retirement in July 1980.* ***Page 6***
- ***Water-cleanup efforts*** *have been delayed by sheer size of construction grants program, other problems, but noteworthy gains have been made, according to EPA.* ***Page 7***
- ***Single chlorophyll molecules, not dimers,*** *are involved in oxygen liberation in photosynthesis reactions, Brookhaven National Laboratory scientists find.* ***Page 7***
- ***Chemicals is leading investment target*** *on a global basis and the major trend in international capital flow is toward the U.S., Conference Board survey shows.* ***Page 7***
- ***Use of sulfur-asphalt emulsion*** *as a paving material seems ready for commercialization with completion of major paving project using the material in Illinois.* ***Page 8***
- ***Three different nitrosamines*** *have been found in air samples taken by NIOSH near hot processes at a tire manufacturing plant in Cumberland, Md.* ***Page 8***

Business

- ***Chemical capital spending,*** *according to C&EN survey of 16 U.S. basic chemical producers, is likely to top 1978 level 13% or more as companies accelerate expenditures to meet budget targets.* ***Page 11***

International

- ***Polyurethane use worldwide*** *may exceed 7 billion lb in 1980—spurred by need to conserve energy, demand rises for rigid foam to insulate buildings, vehicles, and flexible foam to lower auto weight.* ***Page 12***

Government

- ***Fast-track energy projects bill*** *is passed by Senate; House versions to be voted on this month as Congress continues to wrestle with energy legislation.* ***Page 16***

Science

- ***Guidelines from the National Cancer Institute*** *aimed at reducing the risk of cancer by changing eating habits have added fuel to the debate on funding of nutrition research and peer review.* ***Page 20***

News Feature

- ***Stratospheric ozone loss issue*** *is coming under fresh scrutiny. Uncertainties still exist in ozone-depletion hypothesis, but major reports assessing it and offering ways to control chlorofluorocarbons soon will be received by EPA.* ***Page 25***

ACS News

- ***Fifth ACS Congressional Fellow,*** *Thomas Althuis, has completed his year on the staff of the House Science, Research & Technology Subcommittee where he organized hearings on the drug lag issue.* ***Page 36***

Chemical capital spending going strong

Based on first-half 1979 expenditures for new plant and equipment, outlay for full year likely will be up 13% or more over 1978 level

Capital expenditures by U.S. basic chemical producers should be doing well right now, if for no other reason than that companies are running to catch up with their planned spending at the beginning of the year.

Investment for new plant and equipment among 16 basic chemical companies surveyed by C&EN rose 8.6% during the first half of 1979 from the same period a year ago. During the first six months of 1979, the 16 companies spent more than $2.5 billion on new plant and equipment. Last year in the first half, they spent more than $2.3 billion.

The 1979 rate of spending is running well behind earlier predictions. This spring, the identical 16 companies' planned capital spending for the full year was 16.4% above actual spending in 1978 (C&EN, June 11, page 51). So for the rest of the year the companies are going to have to increase spending to meet their targets.

In the first half of 1979, the 16 companies spent 44% of the money that they had appropriated for the full year. This is a little behind the pace last year, when the same group spent 45.3% of their planned funds in the first half.

However, spending generally lags during the first half. One reason is that because of weather January and February are the two hardest months in which to build a plant.

In addition, spending is generally loaded toward the end of the year because companies rush to meet their budgets. "Industry is somewhat like the government," one industry observer comments. "If the money appropriated is not spent in one year, it is difficult for the company to get that money the next." Companies on the low end in rate of spending for the first half, such as Akzona, which has spent only 30% of its budget, and Hercules, which has spent 33%, say they are confident that they will spend the full amount for the year. And some of the companies that have spent 50% or more of their planned budgets say privately that they probably will exceed their targets because of increased spending rates in the second half.

However, in spite of their best efforts, when the final figures were tallied last year's capital expenditures by the companies did not quite match their initial targets. Although seven of the 16 companies spent more than they planned in 1978, capital spending for the group was 97.5% of first estimates.

This year, however, may be different. Despite the slow rate of spending in the first half, third and fourth quarter capital outlays are being fueled by companies' huge cash flows (earnings plus depreciation). Still rising at a fast clip, cash flow likely will do a lot to keep capital spending going through the rest of the year.

Overall, the percentage of budgets actually spent could be more than last year's 97.5% for all of 1979. If so, capital expenditures probably will increase for the full year 13% or more, although initial budgets of the 16 firms rose only 11.8% from 1978.

William Stork, C&EN New York

Capital spending increased 8.6% in first half; spending was 44% of 1979 budget

$ Millions	1st-half capital spending 1979	1st-half capital spending 1978	% change	Planned spending 1979	Planned spending 1978	% change	% of initial budget spent in 1st half 1979	% of initial budget spent in 1st half 1978	% of initial budget spent in full-year 1978	% of actual 1978 spending in 1st half
Air Products[a]	$112.2	$68.3	64.3%	$230	$170	35.3%	48.8%	40.2%	118%	34.2%
Akzona	18.4	16.4	12.2	61	40	52.5	30.2	41.0	106	38.7
Celanese	126	104	21.2	245	230	6.5	51.4	45.2	108	41.9
Diamond Shamrock	126.8	169.1	−25.0	250	300	−16.7	50.7	56.4	95.6	59.0
Dow Chemical	527	476	10.7	1200	1100	9.1	43.9	43.3	97.7	44.3
Du Pont	434	402	8.0	1000	800	25.0	43.4	50.3	98.2	51.1
Ethyl	52.5	51.4	2.1	105	100	5.0	50.0	51.4	95.8	53.7
FMC	118.2	67.4	75.4	230	170	35.3	51.4	39.6	113	35.1
W. R. Grace	119.8	116.3	71.8	450	280	60.7	44.4	41.5	98.3	42.2
Hercules	48.1	71.3	−32.5	145	115	261	33.2	62.0	101	61.6
Monsanto	235.3	264.0	−10.9	575	525	8.7	40.9	50.3	91.4	55.0
Olin	78.5	66.4	18.2	163	200	−18.5	48.2	33.2	81.3	40.9
Pennwalt	34.6	23.9	44.8	68	55	23.6	50.9	43.4	113	38.6
Rohm & Haas	27.4	36.8	−25.5	73	80	−8.8	37.5	46.0	83.0	55.4
Stauffer Chemical	97.8	89.5	9.3	188	190	−1.1	52.0	47.1	106	44.5
Union Carbide	355.0	290.1	22.4	725	750	−3.3	49.0	38.7	91.7	42.2
TOTAL	**$2511.6**	**$2312.9**	**8.6%**	**$5708**	**$5105**	**11.8%**	**44.0%**	**45.3%**	**97.5%**	**46.5%**

Note: Capital expenditures are monies spent on new plant and equipment. a Figures for Air Products are for first two quarters of fiscal 1979.

World polyurethane use heads for 7 billion lb

Key to plastic's gains is energy conservation push—rigid foams as building and vehicle insulation, flexible foams to lower auto weight

Use of polyurethane resins worldwide will be just under 6.6 billion lb in 1979 and may exceed 7 billion lb in 1980. Of the total, 62% is in the form of flexible foam, 23% is rigid foam, and 15% is elastomeric or other types. Major markets continue to be housing and motor vehicles.

Throughout global polyurethane markets, a common impetus for growth has come from energy conservation. The renewed rise of the world oil price has pushed demand for low-density rigid polyurethane foams to insulate buildings, railcars and trucks, heated pipelines and tanks, and liquefied natural gas tankers. On another front, cars made in or for export to the U.S. often have urethane elastomer bumpers to meet U.S. impact-damage regulations.

In addition, auto makers in all countries are increasing the use of energy-saving deep seating—flexible foam molded into single seat units rather than made around metal frames. Meanwhile, the use of flexible foam for furniture seating and mattresses, which grows at a mature 5% per year in industrial countries, is increasing at 10% annually in developing countries.

This global market picture for polyurethane—flexible, rigid, and elastomeric types in construction, transportation, furniture, and bedding—was presented earlier this month at Kunststoffe, the West German plastics exposition in Dusseldorf, by marketing research manager Peter Manno of Upjohn's polymer chemicals division, LaPorte, Tex.

The U.S. accounts for about 40% of world polyurethane use, according to Manno's figures. Of the 2.4 billion lb U.S. market in 1979, 59% is in flexible foams, 25% in rigids, and 16% in elastomeric and other types. The total is up 7.5% from 1978.

Housing is a major U.S. polyurethane market. Of the total 2.4 billion lb U.S. market, 345 million lb goes for building insulation. Although the slowing economy and record high interest rates may have reduced housing starts to an annual rate of 1.5 million, government minimum insulation regulations and tax rebate programs are still producing a 15% growth in polyurethane insulation over 1978.

In an analysis of the 1979 insulation market, Mobay Chemical finds that roofing is the principal use for polyurethane foam. Contractors surveyed told Mobay that 50% of their jobs were for reroofing, 17% for new roofs, and 15% for walls.

The 570 million lb of polyurethanes used in autos in 1979 will be only 1.2% more than in 1978, Manno says. A 23% increase to 80 million lb in elastomers for bumpers and interior parts will be more than offset by a 3.2% decrease in larger-volume flexible foam to 400 million lb for seating, he predicts. The main reason is lowered auto production this year, perhaps 8.7 million cars, many of a smaller size.

The decreased number of U.S. housing starts in 1979 will result in only a 5% increase to 545 million lb in use of flexible foam for furniture seating. In mattresses, a trend to trading up in quality will spark a 10% growth to 170 million lb in this use.

In Canada, whose economic troubles preceded those of the U.S., auto makers may take only 58 million lb of polyurethanes in 1979, about level with 1978. Furniture and bedding use likewise will remain at about 50 million lb, he says. Energy saving will trigger a 20% increase to 23 million lb in building insulation foam however. Overall, Manno estimates total Canadian polyurethane demand at 175 million lb, up 8% from 1978.

Among Latin American countries, Argentina, Brazil, Mexico, and Venezuela account for 86% of the 390 million lb of polyurethanes consumed in that region in 1979, up 10% from 1978. Manno expects an 8% growth in 1979 to 61.2 million lb of polyurethane for auto manufacture in Latin America, spurred by moderation of inflation in Argentina and Brazil. Brazil, which leads in auto production, will use 42 million lb this year.

Though use of polyurethane building insulation in Latin America will rise 18.6% to 28 million lb in 1979, this is far less than the apparent market in the region. Manno ascribes this low volume partly to use of brick and stone as major construction materials, neither of which is well suited to insulating with polyurethane.

Flexible polyurethane foam for furniture will grow 7% to 90 million lb, he estimates. This amount also is much less than market potential because of relatively low consumer income and division of furniture manufacture among many small shops, which have not adopted polyurethane seating. On the other hand, bedding uses will rise 8.7% to 105 million lb, spurred by increased market penetration and trading up to better quality mattresses.

The West European urethane market will be 1.80 billion lb in 1979, rising 4% to 1.87 billion lb in 1980. Eastern Europe will use 300 million lb in 1979 and 10% more or 330 million lb in 1980, Manno predicts. East-West differences in auto-making technology are reflected in the use of 512 million lb of polyurethane for West European cars in 1979, compared with only 2.6 million lb in East European countries. The slowing U.S. economy will limit demand for exported West European cars, though European demand will rise somewhat. The result will be West European consumption of 521 million lb of polyurethane in 1980 autos, East European consumption of 3.1 million lb.

Western Europe will use 237 million lb of rigid foam in building insulation in 1979 and 250 million lb in 1980, Manno says. The growth rate could increase if countries other than West Germany adopt minimum insulation standards. In Eastern Europe, 95 million lb will be used for insulation in 1979 and 108 million lb in 1980.

Polyurethane mattresses will use 412 million lb of flexible foam in Western Europe in 1979 and 430 million lb in 1980. Manno ascribes this low 4% growth to insufficient sales efforts by producers.

By contrast, polyurethane mattresses, because they cost less than mattresses made of other materials,

Global urethane market will top 6 billion lb in 1979

NORTH AMERICA

Millions of lb	Flexible and rigid
Transportation	628
Construction	414
Furniture, Bedding	803
Other[a]	773
TOTAL	**2618**

WESTERN EUROPE

Millions of lb	Flexible	Rigid
Transportation	461.1	51.3
Construction	—	232.8
Bedding	412.8	—
Furniture	380.7	19.4
Other[a]	91.2	149.6
TOTAL	**1345.8**	**453.1**

EASTERN EUROPE

Millions of lb	Flexible	Rigid
Transportation	2.6	—
Construction	—	94.7
Bedding	138.8	—
Furniture	41.0	5.5
Other[a]	2.6	16.5
TOTAL	**185.0**	**116.8**

ASIA

Millions of lb	Flexible	Rigid	Other
Transportation	150.8	11.9	11.7
Construction	—	38.3	—
Bedding	96.9	—	—
Furniture	101.8	6.8	—
Other[a]	105.1	112.9	139.0
TOTAL	**454.6**	**169.9**	**150.7**

SOUTH AMERICA

Millions of lb	Flexible	Rigid	Other
Transportation	56.4	4.8	—
Construction	—	28.0	—
Bedding	104.6	—	—
Furniture	89.2	—	—
Other[a]	30.8	15.9	59.5
TOTAL	**281.1**	**48.7**	**59.5**

AFRICA

Millions of lb	Flexible	Rigid
Transportation	1.1	1.3
Construction	—	10.1
Bedding	89.2	—
Furniture	6.6	0.2
Other[a]	2.2	7.9
TOTAL	**99.1**	**19.6**

MIDDLE EAST

Millions of lb	Flexible	Rigid
Transportation	—	0.4
Construction	—	8.6
Bedding	165.2	—
Furniture	0.7	—
Other[a]	1.5	10.1
TOTAL	**167.4**	**19.2**

Note: Middle East is defined here as Turkey, Syria, Lebanon, Jordan, Israel, Cyprus, Kuwait, Iran, Iraq, Saudi Arabia, and Egypt.
[a] Includes appliances, foundry core binders, carpet underlay, fibers, footwear, textile laminates, and packaging. **Source:** Upjohn Co.

are increasingly popular in Africa and the Middle East. Manno predicts that 165 million lb of flexible foam will be used in the Middle East in 1979 and 176 million lb in 1980. Consumption in Africa will be 89 million lb in 1979 and 99 million lb in 1980. East European use will grow from 138 million lb in 1979 to 145 million lb in 1980.

Continued new housing construction and family formation in Western Europe will produce a growth in flexible foam furniture seating to 380 million lb in 1979 and 388 million lb in 1980. As in the U.S., furniture makers continue to rely on wood, taking only 19 million lb of rigid foam in 1979 and 20 million lb in 1980.

Eastern Europe will use 47 million lb of flexible foam for furniture in 1980, up from 41 million lb in 1979, whereas rigid foam will be 5.5 million lb for both years. Flexible foam furniture consumption will be 660,000 lb in the Middle East in 1979 and 1980. African countries will use 6.6 million lb of rigid and 220,000 lb of flexible foam for furniture in both years.

Molding of polyurethane elastomer shoe soles is an industry that has gravitated from Western Europe to Eastern Europe and the Middle East in recent years, Manno says. Countries in these regions will use 198 million lb of polyurethane for shoe soles in 1979 and 211 million lb in 1980.

Turning to Asian markets, Manno says that Japan uses 66% of the 775 million lb of polyurethane resins produced in Asia and the Pacific region. He estimates 1979 Japanese car and truck production at 10 million units, with more than half of these exported to the U.S.

Manno expects that the Japanese auto industry, as in Western Europe, will suffer from weakness in the U.S. economy. Thus, flexible foam use in Japan's auto industry could drop from 135 million lb in 1979 to 131 million in 1980. On the other hand, increasing use of reaction injection molded (RIM) polyurethane elastomers for fenders and bumpers could raise elastomer consumption to 14 million lb in 1980 from 10 million lb in 1979.

Rigid building insulation foam will take a relatively low 32 million lb share of the Japanese market in 1979, increasing to 35 million lb in 1980. These small use levels persist, Manno says, despite the Japanese government's offer of low-interest loans for installing insulation.

Furniture and bedding are slow-growing but stable markets in Japan, Manno adds. The 86 million lb-1979-use level could increase to 89 million lb of flexible polyurethane foam in 1980.

Overall, Japanese polyurethane use likely will increase from 529 million lb in 1979 to 561 million lb in 1980, Manno says.

Statistics are not readily available from the People's Republic of China, but Manno estimates that current use of rigid foam is 11 million lb and of flexible, 8.8 million lb.

Total polyurethane markets in Australia and New Zealand will be 112 million lb in 1979 and 120 million lb in 1980. Among other Asian countries—South Korea, Taiwan, the Philippines, Hong Kong, Thailand, Singapore, Indonesia, and India—183 million lb of polyurethanes will be used in 1980, up from 161 million lb in 1979.

Australia and New Zealand will use 16 million lb of polyurethanes in autos in 1979 and 1980. Other Asian countries, whose combined auto production is about 330,000 per year, will use 13 million lb in 1979 and 16 million lb in 1980.

Bedding will take 14 million lb of flexible polyurethane foam in 1979 in Australia and New Zealand and almost 16 million lb in 1980. Among other Asian countries, South Korea and Taiwan are the main users of polyurethane foam for mattresses. ☐

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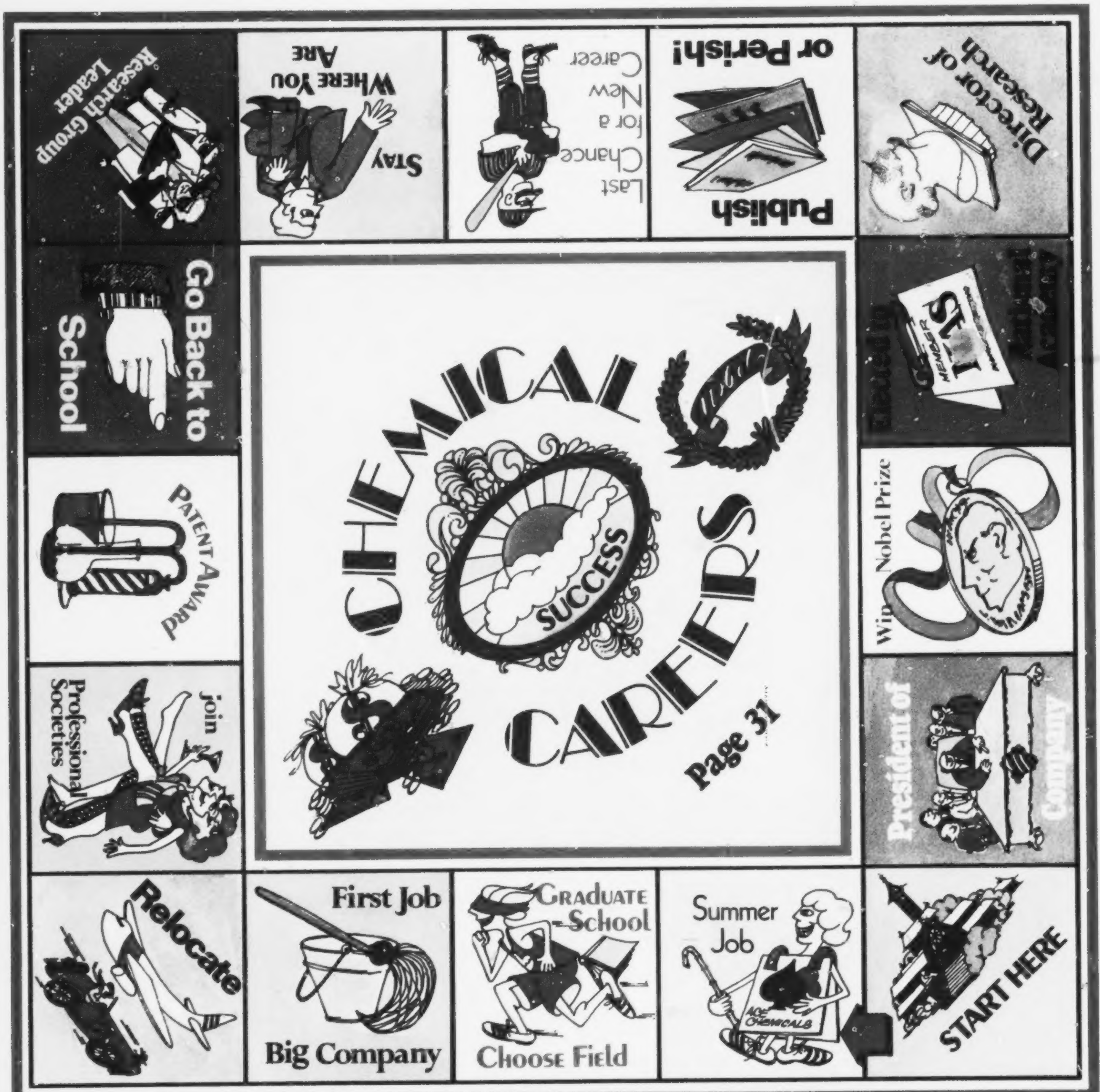
Astrochemistry moves into submillimeter range Page 23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STAY WHERE YOU ARE
Last Chance for a New Career
Publish or Perish!
Director of Research
Elected to National Academy
MEMBER
President of Company
Win Nobel Prize
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News of the Week

- ***Nobel Prize in Chemistry*** *is awarded to organic chemists Herbert C. Brown of Purdue University, and Georg Wittig of Heidelberg University.* **Page 6**
- ***Long-term exposure of groups of rats and mice*** *to formaldehyde apparently has resulted in cancer of the nasal passageway of some male rats, but not mice.* **Page 7**
- ***American Cyanamid is fined $10,000*** *for its management policy that allegedly forces women to be sterilized in order to keep their jobs.* **Page 7**
- ***Radio-frequency electric fields*** *are used to heat deposits of shale oil in Texaco's new process; eliminates mining, retorting, and waste disposal problems.* **Page 8**
- ***New process for making ethylene,*** *called Thermal Regenerative Cracking, limits carbon laydown and promises increased flexibility and lower costs.* **Page 8**

Business

- ***American Cyanamid looks to its research*** *and development buildup in the 1970's, especially in the life sciences, to produce expanding business and rising profits in the 1980's.* **Page 12**

International

- ***With U.S. chemical exports*** *soaring to Europe; chemical industry, political leaders there complain that U.S. oil, gas controls are indirect subsidy for petrochemical firms; U.S. firms marshal rebuttal.* **Page 14**

Government

- ***House Committee cites EPA's failure*** *to meet deadlines on hazardous waste disposal, lethargic enforcement; EPA counters with successes.* **Page 18**
- ***High Court weighs*** *OSHA benzene exposure case; decision may determine point at which federal agencies must consider economic impact of their rules on the regulated industry.* **Page 19**

Science

- ***Bell Telephone Laboratory scientists*** *open submillimeter region to astrochemists—using a refined InSb bolometer, aboard NASA's airborne observatory, to detect interstellar neutral carbon.* **Page 23**
- ***Frequency measurement*** *of specific yellow lines in absorption spectrum of iodine molecule is highest to date; offers new definition of length standard.* **Page 25**

1980 Employment Outlook

Survey of the job outlook *includes reports on the demand for chemists, salaries of chemists, and career guidance information. Recommendations are given on how to improve one's chances of career success.* **Page 31**

Books

- ***Physician argues that toxic hazards of fluorides*** *in water outweigh their dental health benefits, citing his clinical studies of patients to bolster argument.* **Page 56**

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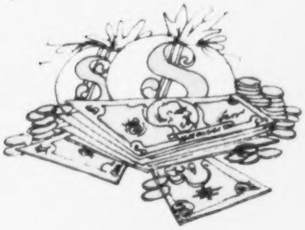

EMPLOYMENT OUTLOOK

Career Opportunities for Chemical Professionals

Although the health of the overall U.S. economy increasingly is coming into question, employment prospects for chemists and chemical engineers still look strong. All signs indicate that employers are at least as active as they were last year in seeking job candidates. And last year was a relatively healthy year for hiring. If anything, this year is even better.

At the latest ACS national meeting, for example, the number of employers with jobs to offer was up about a third. Help-wanted ads in C&EN are running at a higher level now than at any time in more than a decade. And unemployment among chemists, at a rate of 1.1% as of last March, is the lowest since ACS began to measure the employment status of its members in 1971.

Campus recruiting also is holding up well. College placement officials say that as many or more employers seeking new graduates showed up at their schools this year as last. And although some fingers may be crossed, they claim that they see no signs yet of a cutback in interviewing during the year ahead.

Meanwhile, employers of chemists and chemical engineers tell C&EN that they expect to have 2% more chemists and 3% more engineers on their staffs next year than they did in 1979. About 65% of the chemists and 80% of the engineers they expect to hire in 1980 will be new graduates.

These developments and other information pertaining to careers in the field of chemistry are detailed in C&EN's most recent survey of the employment outlook, as reported on the following pages by senior editor Howard J. Sanders.

How to succeed

Success in chemistry depends on making a lot of right decisions. Each individual must choose his own goals and set his own course. But C&EN has asked chemists who already have made their mark in the field for tips on how to get ahead in a chemical career. **Page 32**

Demand

Opportunities for chemists and chemical engineers continue to look bright, as employers remain active in the job market. The pace of campus recruiting shows no sign of slackening. And unemployment among chemists is at the lowest level in a decade. **Page 40**

Salaries

Chemists and chemical engineers are earning more this year. Starting salaries being offered new graduates are well above those of a year ago. But with inflation running rampant, salaries have not been keeping up with living costs, at least for experienced chemists. **Page 46**

Career Planning

A wealth of valuable information and services on chemical careers is available from the American Chemical Society and other organizations. A directory provides names and addresses of many employers of chemists and chemical engineers. **Page 48**

HOW TO

1980

SUCCEED

Chemists offer practical advice on mapping a successful career

So you want to suceed in chemistry. A bachelor's degree with a major in chemistry is needed for openers, of course. But what's your next move? Graduate school, or look for a job? And, in either case, do you aim for a big organization or a small one? What about getting out of the lab and into other types of chemically related work? Or moving to a new location? Can playing company politics give you a leg up? Or publishing papers as often as possible?

Succeeding in chemistry clearly is not a one-decision undertaking. To get some ideas as to how a chemist might improve the chances for success, C&EN has talked with men and women who have made their mark in chemistry. Their views provide a variety of insights into how success may be achieved.

Getting a good, solid grounding in chemistry during college, of course, is essential. Should this be done at a large school or a small one? Many chemists say that it makes no difference. Small schools may not have the high-powered laboratory equipment found in many large universities, but this does not affect the quality of undergraduate training significantly.

One chemistry professor observes, "Thanks to federal research support, many small chemistry departments are a lot better equipped these days than in the past. Besides, the quality of a chemical education depends more on the caliber of teachers than on the sophistication of instruments—particularly at the undergraduate level."

Many faculty advisers recommend that students attend a large university if they prefer a wide variety of courses and a broad range of extracurricular activities. They also recommend a large university to students self-sufficient enough to cope with its relatively impersonal atmosphere.

On the other hand, faculty advisers usually suggest a small college to students who would feel lost on a large, teeming campus. They also point out that a small college offers more individualized instruction.

As for graduate chemistry, most scientists recommend a large school with a highly regarded research faculty. Such schools, they believe, are definitely superior.

Another important question is: How advanced a degree should a person get? To teach chemistry in a university or college, a Ph.D. degree is virtually essential. It also is imperative for the chemist who wants to do research, especially basic research. Says one chemist, "Since most chemists seeking employment as researchers have Ph.D. degrees, a person lacking such a degree is at a serious competitive disadvantage."

Many observers believe, however, that, for production, sales, market research, technical service, or relatively routine laboratory work, a B.S. or M.S. is adequate. Any additional training a person may need can be obtained on the job or through continuing education courses.

Robert A. Alberty, professor of chemistry and dean of science at Massachusetts Institute of Technology, recommends that college students participate as much as possible in such extracurricular activities as clubs and athletic teams to improve their skills in working with other people. "Such skills," Alberty says, "can be of enormous value in later life."

How important are academic grades in determining a person's later professional success? Answers vary. Samuel P. Massie, chairman of the chemistry department at the U.S. Naval Academy, declares, "Good grades help to open doors when you are looking for a job. Employers tend to give appreciable weight to grades in evaluating job applicants because grades are a measure of whether a student has made an effort to develop technical as well as general scholastic competence. Employers, of course, also consider other factors, such as motivation, personality, initiative, creativity, and so on. Obviously, grades aren't everything."

But Alberty observes, "Academic grades can be grossly overrated. Some people are just good test-passers, possibly because they have good memories. They cram for exams and are adept at repeating almost verbatim on tests what their professor said in class. Such a student may get terrific grades. But by blindly accepting everything the professor says, the student may show a lack of judgment and the ability to think independently—talents that will be extremely important in later life. Admittedly, good grades are of value in getting into graduate school and in getting a job. In the long run, however, there are much more important things."

Summer jobs in chemistry, either in industry or at a university, may increase chances of later success. Such work will help to make studies more relevant to future careers. It also provides a clearer idea of what professional work will be like. Moreover, chemistry students who work in industry during the summer probably will find it easier to get permanent employment in industry when they graduate because of this experience.

A summer job also may help a student to decide in which area of industry to work—or, on the other hand, to conclude that a career in industry is definitely out.

Attending universities or colleges having chemistry departments that offer coop programs also has advantages. One professor observes, "Such programs, which alternate periods of study with periods of on-the-job experience, increase a person's chances of later professional success. They give the student valuable work experience and exposure to the practical world. Also important to many students, the pay helps defray part of the cost of their college education."

Alberty of MIT states, "One way to get increased benefit out of your college experience is to develop a friendship with at least one member of the chemistry faculty. This person can serve as a valuable role model for

C&EN staff photo

Niederhauser: a company that has a growing commitment to R&D is a better firm to work for than one whose R&D spending fluctuates with its economic fortunes

you—someone whom you can emulate and who can enhance your own chances of success."

If a graduate ultimately wants to be a chemistry teacher, should he or she first work in industry for several years to gain professional experience? (Many industrial critics complain that a major shortcoming of chemical education is that few chemistry professors have had any exposure to the practical world of industry, even though most of their students will later work in industry.)

Most university chemists say, however, that a person who wants to teach should do so immediately after graduation or postdoctoral studies. They argue that time spent in industry prior to a job in academia is "essentially lost time" that might better be spent in teaching and academic research, partly because these are among the most creative years of a chemist's life. And from a competitive standpoint, people who work in industry will start behind their contemporaries in academic experience and in obtaining tenure.

Some chemistry departments, however, recognize the value of industrial experience for faculty. They urge staff members to take three to 12 months off to work in industry. This type of program is encouraged by some chemical firms that temporarily hire faculty members to acquaint them with industry.

It also is encouraged by the National Science Foundation's Science Faculty Professional Development Program, which was started in 1976 to provide financial support to between 80 and 100 university science teachers a year to work for limited periods of time in industry (in some cases, these teachers work in schools other than their own).

In selecting a company to work for, should a graduate pick a large company or a small one? Most observers believe it preferable for a chemist to work first for a large firm because a large company provides a better learning experience.

James D. D'Ianni, former assistant to the vice president of research at Goodyear Tire & Rubber Co. and now president-elect of the American Chemical Society, says, "When you work as a laboratory chemist for a large firm, you are apt to deal with a broader range of research problems because the company is more diversified. You are likely to have better equipment to work with. If you run into difficult research problems, you have a greater number of expert, in-house scientists to turn to for assistance. Moreover, in a large company, you are more apt to learn about the latest, most efficient ways of doing things. All this is part of a valuable learning process for the beginning chemist and can increase considerably his or her chances of getting ahead in the professional world."

Of course, working for a small company has advantages. You may be promoted to a responsible position sooner. The results of your laboratory efforts may be commercialized more quickly. You may have greater freedom of action. Says one chemist, "If you like to be fairly independent, you may be happier working in a small organization."

Warren D. Niederhauser, director of pioneering research at Rohm & Haas, says, "As far as I am concerned, the most important factor in choosing a chemical company to work for is not the size of the company but its growth prospects. How fast you advance can depend on how rapidly your company advances." He recommends that chemists considering employment with a firm study its recent annual reports. He also suggests discussing its business prospects and the quality of its top management with a knowledgeable stock broker.

Niederhauser also urges chemists to consider a company's record on research and development spending. A firm that has a strong and growing commitment to R&D is a better place to work than one whose R&D spending fluctuates with its economic fortunes. He further cautions, "Be wary of companies that have periodic, large-scale layoffs of technical personnel."

In some chemists' view, one of the best ways to get ahead is to change jobs relatively often. Some, in fact, flatly declare that all chemists wishing to improve their financial status should change jobs at least once within the first three years of entering the profession. They argue that no company will appreciate your services or compensate you as much as will a new employer.

Many chemists, however, regard such reasoning as hogwash. The value of job-hopping, they say, has been grossly misrepresented.

Esther A. H. Hopkins, a senior projects administrator at Polaroid, says, "Of course, if you and your boss are constantly at loggerheads and your working conditions are abominable, you obviously should change jobs—and the sooner the better. But certainly do not change jobs merely to increase your salary. If you like the work and feel you have a good future with your organization, stick with it. Too many people change jobs to gain tempting but very short-term advantages."

Says Blaine C. McKusick, assistant director of Du Pont's toxicology laboratory, "People who switch employers a great deal may be regarded as using their jobs merely as stepping-stones. After three or four switches, it may look like a person can't make up his mind about what he wants to do. If you are primarily interested in changing employers to increase your income, your new salary

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should be at least 30% higher than the old one. In any event, don't change jobs on the theory that this is the only way to get ahead."

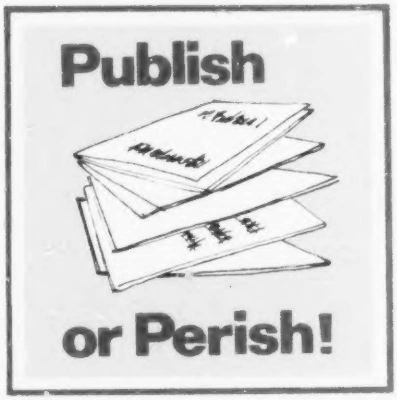
Some observers point out that most organizations today have a policy of promoting from within. Thus, employees do not have to leave to get a promotion. More companies recognize that such a policy can reduce the loss of valuable employees.

In 1977, ACS surveyed its members to find out what effect repeated job changes have had on their salaries. The results showed, surprisingly, an inverse relationship between number of employers and salary at all degree levels and most experience levels.

In 1977, the mean annual salary of full-time-employed ACS members with B.S. degrees and 20 or more years of professional experience was $28,713 for those who had worked for only one employer, but $27,017 for those who had worked for four. The mean annual salaries were $38,392 for Ph.D.'s with only one employer but $32,062 if they had had four employers.

The survey suggests that chemists who change employers relatively often may lose the seniority needed to advance into high-paying positions. Large, well-established employers also may be leery of hiring job-hopping chemists because they are viewed as unstable or as having been eased out of former jobs because of incompetence.

Patricia A. M. Figueras, a chemist who is head of computer and financial services at Eastman Kodak Research Laboratories, emphasizes that chemists should be flexible in terms of the jobs they are willing to tackle. Some people who go into industrial research, she says, want to spend their professional lives continuing the research they did in graduate school. "That's no way to get ahead," she comments. "After all, the time may come when your company no longer has an interest in the type of research you are doing because its business activities have changed."



McKusick: people who switch employers a great deal may be regarded as using their jobs merely as stepping-stones to employment elsewhere

She urges chemists to be open to new opportunities—to take on research in the polymer area, for example, even if their previous experience has been with agricultural chemicals. The new job will require a rapid education in the polymer field, but the experience should expand your scientific horizons.

Many scientists advise those who start out in a research job to be willing to take on an entirely new assignment outside the laboratory. This might be in market research, sales, personnel work, toxicology, industrial hygiene, technical service, or whatever.

To succeed, should you feel obliged to accept a new job in the organization if it will require you to move to a new location? Many observers say that, unless you have some overriding personal reason for not wanting to move, you certainly should.

In most cases, the move will be a promotion, as well as a stepping-stone to a higher position later, since it will broaden a person's outlook and experience.

Ellis K. Fields, a research consultant at Amoco Chemicals, says "By all means, be willing to move if your supervisor wants you to. After all, the more you please your boss, the more likely he is to please you."

Some people say that an employee runs the risk of damaging his or her prospects by turning down a transfer more than once. Superiors may interpret this to mean that other interests have higher priority than his or her professional career.

Of course, changing jobs and locations in a company can have its hazards. Some years ago, a chemist reluctantly transferred to a position as manager of a company division that was in financial trouble. When the shaky operation collapsed, much of the blame was unfairly leveled against him. As a result, his professional career suffered irreparably.

Success, of course, depends on good work habits. That means, in part, the ability to work hard. It also means being willing to work overtime to complete a job.

Fields of Amoco says, "A chemist, of course, is not expected to work routinely 14 hours a day, seven days a week. Supervisors realize that a person has responsibilities not merely to a job but also to family, community, and other interests. However, when the need arises, one should be willing to put in extra time. And one should do this not because a supervisor insists on it but because of an eagerness to complete work properly and on time. People who succeed are not clock-watchers."

Niederhauser of Rohm & Haas points out, "To succeed as a research chemist in industry, you need to be productive. The people who get ahead are the ones who contribute most to the company by being the most creative. Obviously, a chemist must exercise good judgment in selecting research goals and the ways to achieve them. At the higher levels of management, this requires both good scientific judgment and good business sense."

Many scientists emphasize the need to develop laboratory skills. For example, Fields of Amoco cautions, "In your research projects, don't collect reams of meaningless data. Un-

Figueras: chemists should welcome new job opportunities in a company because they can be intriguing and challenging and can expand a person's scientific horizons

fortunately, computers make that all too easy to do these days. By all means, don't use a computer as a substitute for thinking."

Work should be planned. Fields recommends that, every working day, chemists write down the things they hope to accomplish tomorrow. Although few people follow such a formal procedure, they do look ahead to what they should be doing tomorrow, next week, or next month.

David C. Young, a senior research specialist at Dow, comments, "An excellent work habit is to assign priorities to your work so that you get the most important things accomplished. Don't get bogged down in minutiae. And be sure to budget your time so that you meet deadlines."

David R. Lide Jr., a chemist who is chief of the National Bureau of Standards' Office of Standard Reference Data, says, "Good chemists know to stop working on a project when they can use time better on some new undertaking. They do not milk a project merely to achieve some small additional benefit. Good chemists halt a project when it becomes clear that further effort will be fruitless. On the other hand, they must be willing to persist in a task even in the face of repeated failure and disappointment. Of course, deciding when to stop a project is always difficult."

A good work habit, say many chemists, is to do the hardest jobs first and save the easiest ones for last. Too many people do just the opposite—and make their work more difficult and less productive. For many people, that means doing the hardest job at the start of the workday, when the mind is clearest and less cluttered.

Mary E. Carter, head of USDA's Southern Regional Research Center, recommends, "Do your hardest jobs when you know by experience that you perform your best work, which is not the same time for everybody. Some people work best right after lunch."

W. Thomas Lippincott, professor of chemistry at the University of Arizona, urges chemists to go off periodically to some isolated place where they can devote themselves totally to serious scientific thought—away from the telephone, laboratory hubbub, gossip with coworkers, and other distractions. "To be creative," he says, "you sometimes have to focus your attention solely on chemical problems and forget all others."

Apart from having good work habits, most successful chemists also work well with other people, are well liked, and are willing to spare the time to be helpful to others. This is not universally true; some outstanding chemists have less than glowing personalities. Says Young of Dow, "Functioning well with other people as a method of getting ahead professionally means not only getting along on a friendly basis with people above you but also with those on the same level or below you—everyone from chemists, production workers, and technicians to electricians, pipefitters, and laboratory dishwashers. It is not only a matter of decency; your success depends on their continuing cooperation. You can't make adequate progress in your own work unless you are on friendly terms with all of the people whose help you need."

Success can be measured in many ways

Success is a highly personal matter. How one person measures it may be of little or no consequence to another.

Doubtless, the most widely used indicator of success is a person's income and the value of his possessions. Says one industrial chemist, "Since money is such a frequent measure of success, rarely will a person turn down a job that will increase his salary substantially. He may worry that the position will give him an ulcer, but he usually will accept it anyway."

Other people measure success primarily by how much they enjoy their work. If they like their jobs, salary is strictly secondary—as long as it is adequate. Lester C. Krogh, vice president of 3M's commercial chemical division, declares, "No salary is high enough to compensate you for doing a job that you thoroughly dislike."

Many scientists measure success chiefly by their professional accomplishments. This often is reflected in the number of their publications and patents, as well as lectureships and awards.

Another indication of success is the esteem of associates, as evidenced by how often they seek you out for your knowledge and judgment or appoint you to advisory boards.

Other people gauge success in terms of power—the ability to control the lives of others or to influence decisions and change the course of events.

In other words, each person defines success in his own way.

Milton Harris, a former director of research who is now a government and university adviser, says, "Most successful chemists, especially those who direct the work of others, are people-oriented. In other words, they have a sympathetic understanding of the needs and aspirations of other people."

USDA's Carter says, "I believe being people-oriented is more important among managers than among laboratory chemists. Lab chemists generally have fewer dealings with people. A lab person has to be primarily research-result-oriented. Some quite creative scientists are basically loners. Their ideas, therefore, often have to be carried forward by other research workers."

Discussing desirable personality traits, Kodak's Figueras says, "One thing I find important is the need to be patient with the people you work with. You should realize that not everyone will do a job as fast as you can, or will do it in the same way. You should give people the freedom to do a job in their own way—within reason, of course. Otherwise, you run the risk of frustrating and antagonizing people."

Lide of NBS comments, "A successful chemist understands the strengths and weaknesses of people and makes the greatest use of their strengths. In many cases, you do not have the freedom to select all of the people who work for you. Thus, you must make a very careful effort to use the people available to you in the optimum way."

One chemical executive observes, "Good scientists, as well as good managers, understand a problem quickly. They get to the heart of the problem and don't waste time with extraneous details."

Carter of USDA says, "Successful chemists develop the habit of thinking innovatively. They are not content to continue doing things in the same old ways. They also are open to the new ideas of others."

People who are successful also have marked ambition. They succeed because they have a driving desire to achieve their goals. But Lide comments, "Having driving ambition does not mean that you have to be ruthless. The drive is within yourself; it is not necessary to ride roughshod over other people. Some of the most successful chemists I know are exceptionally humane, gentle, and self-effacing people. Yet they are highly ambitious and have a keen desire to succeed."

Is playing office politics—by deliberately ingratiating oneself with one's superiors to gain special favors or promotions—a factor is achieving success?

Says Harris, "Human nature being what it is, I believe that office politics is a factor in just about every organization. However, I don't think it is nearly as important among chemists as among other people in industry. Scientists tend to be promoted primarily on the basis of their technical competence and other qualifications."

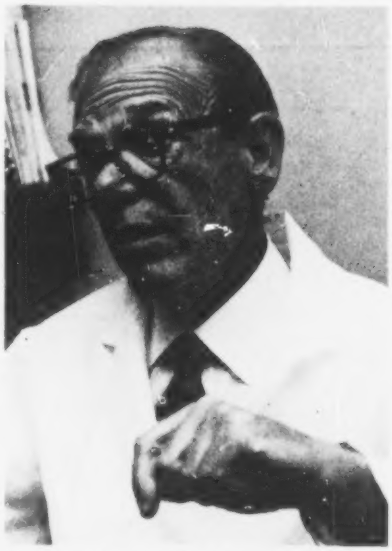
An industry executive comments, "If two people have equal qualifications for a job, it is only natural for you to promote the person you know best and like the most. What's wrong with that?" Another observer retorts, "Yes, but how often are two people equally qualified? The problem with office politics is that less-qualified people often are promoted because they have curried favor with top managers. Most chemists are promoted because of their abilities, however, and not because they have cozied up to the 'right people.' "

To increase his or her chances of success, a chemist should keep scientifically up-to-date by reading chemical magazines, journals, and books. Many people recommend that chemists also read publications in related scientific fields. As one chemist puts it: "Sometimes, an article in a physics or biology journal can give you stimulating ideas useful in your own work." Says one company manager, "People who get ahead are those who are interested in almost everything and read very broadly."

Many chemists stress the need to attend scientific meetings and conferences to obtain up-to-date information and helpful new ideas. Also useful is the chance for informal discussions with colleagues in other organizations.

Fields declares, "I think that attendance at meetings is so important that I believe a chemist seeking a job should make sure that the organization has a liberal policy regarding participation in meetings. Such participation certainly can expand a chemist's outlook."

Scientific education obviously does not end with a university diploma. Continuing education courses are one way to keep abreast of a field. Many chemists take continuing education courses either at their company or at nearby universities or colleges. Many take ACS Short Courses or similar courses offered by other organizations.



Fields: scientists should be quite willing to put in extra time on the job whenever it is necessary, so that the work is completed properly and on schedule

Says one chemist, "Since in-depth knowledge of a field is one key to success, I am in favor of taking as many continuing education courses as possible. Many firms, of course, pay part of the cost of such programs."

A chemist's reputation can be enhanced by writing articles or books. An outstanding review article or a college chemistry textbook can lead to international fame.

Some people assume that the more articles they write the better. Others emphasize that quality is more important than bulk. Says one chemist, "Stretching into three or four papers information that could be published in one merely clutters the literature. Also, it earns for the author an unfortunate reputation for being more concerned with the number of his publications than with their value."

Chemists frequently stress the need to write and speak well. They point out that the advancement of many chemists has been impeded by their inability to convey ideas to others. A brilliant idea, if not comprehensible to others, may come to naught.

Chemists also must be able to speak in a clear and convincing manner. Also important is the need to tailor one's presentation to the audience. A talk loaded with technical jargon and abstruse scientific concepts can antagonize an audience, if not put it to sleep.

Hopkins of Polaroid says, "If you feel your writing is not as good as it should be, I'd recommend that you take continuing education courses in English and in technical report writing. I'd also urge you to read good writing regularly and analyze for yourself why it reads so interestingly and fluently."

Up to a point, a research chemist, to increase his or her salary substantially, does not need to give up a laboratory job to become a manager. A highly productive and respected chemist may not earn as much as a vice president but may well earn as much as a top research manager.

This situation has changed radically in the past 25 years. Before then, scientists often left the laboratory because they felt that the only way to get ahead was to become a manager. But some chemists who are good researchers have little or no talent for directing the work of others and thoroughly dislike doing so. They would contribute far more to their organizations if they remained in the laboratory, which they would do if they were paid more.

This led many companies to develop the "dual ladder" of advancement. One ladder is for research workers; the other is for managers.

Under this system, top researchers receive salaries and perquisites similar to those enjoyed by their managerial counterparts. Hence, many scientists no longer feel under pressure for monetary reasons to seek positions that they really do not like. Lester C. Krogh, vice president of 3M's commercial chemical division, comments, "Fortunately, because of the dual-ladder system, scientists now are able to stay where they do their best work."

Says USDA's Carter, "Many skilled chemists who have been rewarded with prestigious titles, ample salaries, and the esteem of their colleagues are quite satisfied in the laboratory. They have decided what they want to do most, and they are happily doing it. On the other hand, many chemists genuinely prefer to leave the laboratory and move up the managerial ladder. And they have done so with notable competence. Both can be said to have achieved professional success." □

Go Back to
School

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1980
DEMAND

Demand for chemists is good this year, is likely to hold up in 1980

Despite concern over the slowdown in the nation's overall economy, the employment picture for chemists and chemical engineers continues to look good. For the time being, employers seem to see little or no need to cut back their hiring of chemical professionals.

In the Employment Clearing House at the ACS fall 1979 national meeting, recruiting activity was healthy. Substantially more employers interviewed job applicants than at the fall 1978 ACS national meeting. However, because considerably more job applicants also showed up this year, the average number of interviews per applicant was less.

In March 1979, the unemployment rate among ACS members was lower than at any time in recent years. And the volume of "positions open" advertising in C&EN has been decidedly higher all this year than it was during any period of 1978.

In all, the various indicators of demand show that most employers see an expanding need for chemists and chemical engineers. Clearly, the job situation today is vastly better than it was in either of the two recessions of the early and mid-1970's.

On college campuses, for example, recruiting was at least as brisk this past year as it had been a year earlier— and the previous year itself had been a strong one compared to earlier in the decade. College placement officials, moreover, are generally encouraged about job prospects for their students. The current cloudy business climate, they claim, does not seem to be putting a crimp in employers' plans, at least to date, to look for new graduates between now and next June.

Rebecca J. Simon, placement director of the University of Illinois' school of chemical sciences, reports that 192 employers recruited at the school both in academic year 1977–78 and 1978–79 (the figure was 171 in 1975–76). Although the number of man-days that employers spent interviewing on campus dropped from 364 in 1977–78 to 309 in 1978–79, student interviews rose from 3059 to 3631.

Simon adds that the recruiting outlook for the coming months "looks good for our job candidates." Many employers who regularly recruit chemists and chemical engineers at the school already have signed up for interviewing in the coming months. Furthermore, employers who have not come to the campus in several years also have scheduled visits. "Apparently, the slump in the national economy," Simon says, "has not had much impact on the number of interview schedules requested by employers."

Jean E. Eisel, director of career services for the colleges of arts and sciences at Ohio State University, notes that 56 organizations came to interview its graduating chemists in 1978–79, up from 41 in 1977–78. Employers in the most recent academic year generally had more job openings to fill than in the previous year. "In addition, many employers," she says, "either sent more recruiters (perhaps two instead of one) to interview graduating chemists or spent more interviewing time on campus (perhaps three days instead of two)." Recruiters showed an exceptional interest in hiring B.S. chemists and a greater-than-usual interest in hiring Ph.D. chemists.

About the same number of organizations are scheduled thus far to interview Ohio State's graduating chemists in 1979–80 as was the case at this time last year. "The situation looks good now," Eisel says, "but employers, of course, can always cancel out. Obviously, there is considerable concern about the possible effects of a further downturn in the economy."

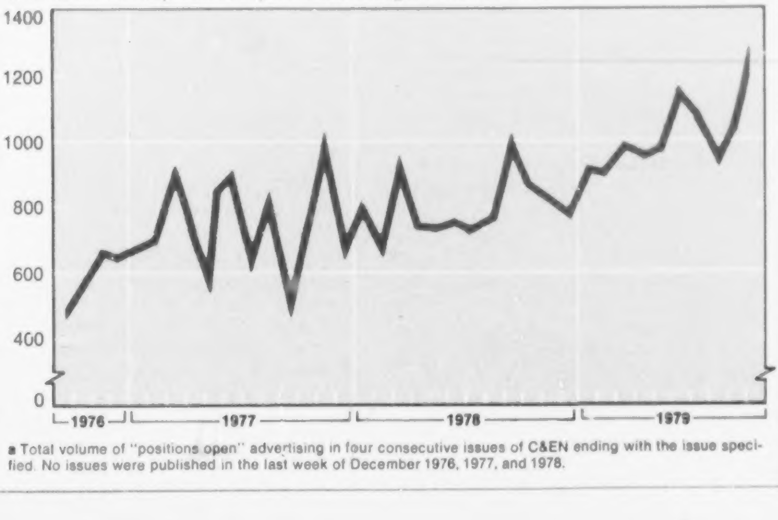
At the University of North Carolina, Chapel Hill, 34 employers came to recruit chemists in 1978–79, four more than in 1977–78. Joseph M. Galloway, director of the university's placement office, notes a definite improvement in the past year in the demand for chemists, "spurred by the need to solve the nation's energy and pollution problems, improve industrial processes, and develop new chemical products."

He adds that "employers are trying to make up for the slowdown in their hiring of chemists in the early 1970's. Moreover, since companies now are making relatively high profits, they have more money to spend on R&D."

At the University of Wisconsin, 76 employers interviewed graduating chemists in both 1977–78 and 1978–79. This past academic year, employers had an unusually large number of job openings, says Audrey L. Aylesworth, the school's chemistry placement coordinator. Some who

Recruitment advertising hits new high

Volume of C&EN "positions open" advertising,[a] column-inches



[a] Total volume of "positions open" advertising in four consecutive issues of C&EN ending with the issue specified. No issues were published in the last week of December 1976, 1977, and 1978.

originally planned to spend only two days on campus recruiting chemists ended up spending three.

The employment outlook for Ph.D. chemists appears to be improving, she reports. The university's 23 Ph.D. chemistry graduates who accepted industrial positions in 1978-79 received a total of 62 job offers—about three per graduate. "In 1975," she comments, "if a Ph.D. chemist got one offer, he felt extremely fortunate." The employment picture for graduating B.S. chemists at the University of Wisconsin also is good. "Last year, our average job-hunting B.S. chemist," she estimates, "received about two offers."

Aylesworth further points out, "I expect a good recruiting year in 1979-80. We are getting lots of inquiries from employers and, to date, have had no cancellations of interviews. Fortunately, we have yet to see any effects of a business setback."

At the University of California, Berkeley, the number of employers interviewing graduating chemists and chemical engineers has changed little in the past two academic years; 43 interviewed chemists in both 1977-78 and 1978-79 (it was 33 in 1975-76), whereas the number that spoke with chemical engineers declined from 96 to 94 (it was 66 in 1975-76).

Although a few of Berkeley's graduating B.S. chemists had a hard time finding jobs, some received as many as six offers. Almost all of the graduating B.S. chemical engineers readily obtained employment.

Among the major recruiters of the university's graduating chemists and chemical engineers are petroleum and petrochemical companies, says Peggy Dempsey, technical placement adviser in the university's Career Planning & Placement Center. Electronics companies increasingly are seeking chemists and chemical engineers for R&D work on new materials and processes. In addition, companies developing new energy sources, she adds, are eagerly searching for qualified new chemical professionals.

Dempsey says, "I have seen no reflection of the nation's economic decline in terms of the number of job openings currently listed in our office and the number of employers who have scheduled recruiting visits. Frankly, I am quite optimistic about the job prospects for our technical graduates of all types in 1979-80."

The healthy demand for chemical professionals was shown last month by the lively activity at the ACS fall meeting in Washington, D.C., where 368 employer representatives used the Employment Clearing House, compared to 273 at the fall 1978 ACS national meeting in Miami Beach. By contrast, only 206 employers used ECH at the fall ACS meeting in Chicago in the recession year 1975.

Job applicants at the latest ACS national meeting totaled 589, compared to 339 in the fall of 1978. The number of positions listed at ECH for candidates' review in fall 1979 was 536, in contrast to 452 in fall 1978. The number of job interviews was 2279, compared to 1732 in fall 1978.

Even though the number of job interviews increased at the latest ACS national meeting, the number of job applicants rose even more. As a result, the average number of interviews per candidate declined to 3.9, compared to 5.1 in fall 1978. The average, however, was only 2.3 interviews per candidate in fall 1975.

Audra B. Rafter, manager of ACS Employment Aids Office, which operates ECH, reports that the largest number of job openings at the latest ECH was for polymer chemists. In previous years, the largest number had been for analytical chemists. At the fall 1979 meeting, the five types of job openings most often listed by employers were for polymer chemists (99 positions), analytical chemists (87), chemical engineers (62), organic

C&EN survey finds job prospects encouraging

C&EN's annual survey of major U.S. chemical employers indicates that employment prospects for chemists and chemical engineers are good. Between mid-1979 and mid-1980, these employers plan to expand their staffs of both chemists and chemical engineers. Although they expect to visit fewer colleges and universities to recruit chemists and chemical engineers in academic year 1979-80, they still intend to hire substantial numbers. The employment outlook for chemists, however, is not so good as that for chemical engineers.

Employers responding to the survey say they hired 14% more chemists in 1979 than in 1978. They expect to hire 6% fewer chemists next year than this year. The employers hired 39% more chemical engineers in 1979 than in 1978. Their hiring of chemical engineers in 1980 is expected to be 1% greater than in 1979.

Of the chemists hired, 58% were new graduates in both 1978 and 1979 and are expected to be 65% of the total in 1980. Of the chemical engineers hired, 72% were fresh out of school in 1978, 75% in 1979, and 81% are expected to be in 1980.

Employers report that the number of chemists on their staffs in mid-1979 was 2% greater than in mid-1978. The number also is expected to be 2% greater in mid-1980 than in mid-1979. For chemical engineers, the growth in staffs is expected to be 3% in both of these periods.

Respondents say that they made 5% more visits to colleges and universities to recruit chemists in academic year 1978-79 than in 1977-78. The number is expected to be 4% less in 1979-80 than in 1978-79. Visits to colleges and universities to recruit chemical engineers increased 8% in 1973-79 from 1977-78. The number is anticipated to be 3% less in 1979-80 than in 1978-79.

About 75% of employers say they are looking for chemists with specialized skills. This year, the specialists in greatest demand are, in descending order, analytical chemists, organic chemists, polymer chemists, and physical chemists. Last year, the top four were: polymer, analytical, organic, and physical chemists. Among many other types of chemists being sought by employers this year are specialists in inorganic chemistry, catalysis, biochemistry, geochemistry, pharmaceutical chemistry, and organometallic chemistry.

The employment picture for women chemists and chemical engineers is slowly improving. Employers report that women comprised 8% of their chemical personnel in both mid-1978 and mid-1979 and are expected to constitute 9% of their chemists in mid-1980. Respondents say that women constituted 3% of their chemical engineers in both mid-1978 and mid-1979 and are likely to comprise 4% of their chemical engineers in mid-1980.

The C&EN survey covers 42 employers of chemists and chemical engineers. These employers are mainly companies in the chemical industry, although they also include some firms in such allied industries as petroleum, rubber, pharmaceuticals, and food, as well as a few research institutes.

Not all respondents answered every question. The 34 organizations that reported the size of their chemical staffs indicated that, in mid-1979, they employed 14,252 chemists and 15,832 chemical engineers.

Employers generally believe that job prospects for chemists and chemical engineers in their organizations will be favorable during the next five years. Some 55% say the outlook for chemists is either very good or excellent, 36% say good, and 9% say fair. Fully 82% of the respondents say prospects for chemical engineers are either very good or excellent, 9% say good, and 9% say either fair or poor.

Number of B.S. degrees in chemistry and chemical engineering rose in 1977–78, but Ph.D.'s decreased

Academic year	Degrees awarded in chemistry[a]			Degrees awarded in chemical engineering		
	Bachelors	Masters	Ph.D.'s	Bachelors	Masters	Ph.D.'s
1967–68	10,847	2014	1757	3211	1156	367
1968–69	11,807	2070	1941	3557	1136	409
1969–70	11,617	2146	2208	3720	1045	438
1970–71	11,183	2284	2160	3815	1100	406
1971–72	10,721	2259	1971	3663	1154	394
1972–73	10,226	2230	1882	3636	1051	397
1973–74	10,525	2138	1828	3454	1045	400
1974–75	10,649	2006	1824	3142	990	346
1975–76	11,107	1796	1623	3203	1031	308
1976–77	11,322	1775	1571	3581	1086	291
1977–78	11,474	1892	1525	4615	1237	259

a Does not include biochemistry and geochemistry. Source: HEW's National Center for Education Statistics

chemists (57), and physical chemists (30). As usual, the demand for inorganic chemists was relatively low (13), although not so low as it has been at some ECH's (only two positions were offered in fall 1977).

According to the Office of Personnel Management (formerly the Civil Service Commission), the federal government's hiring of chemists has been declining in the past few years. It dropped from 601 in fiscal 1977 (an unusually good year) to 475 in fiscal 1978 and to an estimated 400 in fiscal 1979. In these same years, hiring of chemical engineers remained fairly constant at 58, 62, and 60, respectively.

These figures cover hiring of chemical professionals by about 80 federal agencies in the "competitive" civil service system, which does not include such "excepted" agencies as the Federal Bureau of Investigation, the Central Intelligence Agency, and the Tennessee Valley Authority. Moreover, these data do not include high-level personnel in the "supergrades" above grade 15.

According to William E. Robinson, a program manager at the Office of Personnel Management, 8256 chemists were on the staffs of the competitive federal agencies in October 1978. The number of chemical engineers was 1465.

The College Placement Council, Bethlehem, Pa., says that college recruiting at the bachelor's level in 1978–79 was probably the most active in the 19-year history of CPC's annual surveys. These surveys provide information on job offers made to graduating students in a wide range of fields at a representative group of colleges and universities (now 161) throughout the U.S.

Bachelor's-degree candidates received 17% more offers in 1978–79 than in 1977–78. On the other hand, master's-degree candidates received 16% fewer offers, and Ph.D. candidates got 7% fewer offers.

The council also indicates that employers made 24% more offers in 1978–79 than in 1977–78 to engineering graduates at the bachelor's-degree level. Engineering graduates, in fact, received 61% of all bachelor's offers in 1978–79. The number of offers made to chemical engineering graduates, which accounted for 10% of the total B.S. volume, was up 19% in 1978–79 compared to 1977–78.

The number of offers made to graduating B.S. scientists increased 9% in the past academic year. The biggest growth occurred in the computer science field; job offers to B.S. computer scientists rose 26% over those in 1977–78 and 71% over those in 1976–77.

CPC also reports that women with bachelor's degrees received 21% of all job offers in 1978–79. This is the same percentage as in 1977–78 but was a considerable gain over the 13% of 1974–75.

The number of chemists and chemical engineers whom employers can hire is affected significantly by how degrees are awarded in these fields. Between academic years 1976–77 and 1977–78, the number of people who received bachelor's degrees in chemistry (excluding biochemistry and geochemistry) grew from 11,322 to 11,474, according to the National Center for Education Statistics. In the same period, Ph.D. degrees awarded in chemistry slipped from 1571 to 1525. In fact, Ph.D. graduates in chemistry have been declining every year since 1969–70's high of 2208.

Bachelor's degrees in chemical engineering rose sharply from 3581 in 1976–77 to 4615 in 1977–78, the most ever. Back in 1967–68, for example, only 3211 chemical engineering graduates received bachelor's degrees. The trend for Ph.D.'s in chemical engineering is just the reverse, falling from 291 in 1976–77 to 259 in 1977–78. Actually, the number of chemical engineering Ph.D. degrees has been decreasing every year since 400 students were awarded the degree in 1973–74.

Unemployment among chemists continues to decline. According to a survey of close to 11,000 ACS members, 1.1% were unemployed but seeking employment as of March 1, 1979. This compares with 1.4% on March 1, 1978, and 1.5% on March 1, 1977. By contrast, the unemployment rate among the total civilian labor force was 5.7% in March 1979, 6.2% in March 1978, and 7.4% in March 1977.

Among male members, 1.0% were unemployed but seeking employment on March 1, 1979, compared to 1.2% on March 1, 1978, and 1.3% a year earlier. Among female members, the comparable figures were 2.3%, 2.8%, and 3.4%, respectively. As these figures show, the job picture for female members is improving.

A chemist who is unemployed but seeking employment may remain jobless for some time. Among the survey respondents who were unemployed at any time during the year ending March 1, 1979, 26% were without work for up to three months, 44% for three to 12 months, 22% for 12 to 36 months, and 8% for 36 months or more.

According to the American Institute of Chemical Engineers, only 0.4% of its members were unemployed in February 1979, the same as a year earlier. By comparison, 3.7% of its members were without jobs in mid-1971. The median length of time that an AIChE member remained unemployed during the survey period was three months. The median length of time reported in the 1978 survey was only two months and in the 1977 survey six months.

The volume of "positions open" advertising in C&EN, a useful indicator of how actively employers are seeking chemists and chemical engineers, has been exceptionally large this year. Between January and early October 1979, the volume of such advertising in four consecutive issues of C&EN exceeded 900 column-inches 10 times. On the other hand, between January and early October 1978, it exceeded 900 column-inches only twice.

The four consecutive issues of C&EN ending with Oct. 1, 1979, carried 1284 column-inches of "positions open" advertising. Such C&EN advertising this year is, in fact, the largest since 1967. □

1980
SALARIES

Salaries of most chemists rise but lose ground to inflation

Between March 1978 and March 1979, the median salaries of experienced chemists rose 7% for B.S.'s, 4% for M.S.'s, and 6% for Ph.D.'s. On the other hand, initial salaries of B.S. chemists fresh out of school this year were 14% higher than starting B.S.'s received a year ago, 13% higher for new M.S.'s, and 10% higher for this year's crop of Ph:D.'s.

During this period, the consumer price index, unfortunately, climbed 10%. Thus, salary increases did not keep pace with inflation for experienced chemists, no matter what their degree. Newly graduated chemists, however, fared somewhat better in salaries.

These are among the results of two annual salary surveys carried out by ACS's Office of Manpower Studies. One survey, which covers only ACS members, was issued in midyear as the 1979 Report of Chemists' Salaries and Employment Status (C&EN, June 25, page 39). The other deals with inexperienced chemistry and chemical engineering graduates (those with 12 months or less of professional experience), many of whom are not ACS members. Its findings will be published in early November as the 1979 Survey Report of Starting Salaries and Employment Status of Chemistry and Chemical Engineering Graduates.

The 1979 salary survey of experienced chemists and chemical engineers was based on responses from close to 11,000 ACS members who reported their annual salaries as of March 1, 1979. The survey indicates that the median annual salary of B.S. chemists, at all professional experience levels, rose 7% from $22,000 in 1978 to $23,500 in 1979. For M.S. chemists, the median increased 4% from $24,000 in 1978 to $25,000 in 1979. Among Ph.D.'s, the median rose 6% from $27,400 in 1978 to $29,000 in 1979.

The survey also indicates that the median annual salary of ACS-member B.S. chemical engineers climbed 6% from $30,000 in 1978 to $31,700 in 1979. The median for M.S. chemical engineers declined 2% from $32,000 in 1978 to $31,500 in 1979. For Ph.D. chemical engineers, the median rose 9% from $32,000 in 1978 to $35,000 in 1979. Harry J. Foxwell, statistician in the ACS Office of Manpower Studies, believes that the apparent 2% decline in the median salary of M.S. chemical engineers may well have resulted from sampling errors because this group consists of relatively few people.

The median annual salary of members of the American Institute of Chemical Engineers (at all degree levels) increased 7% from $27,500 in 1978 to $29,500. Typically, the median salaries reported by AIChE members are smaller than those reported by ACS mainly because the former are younger than the chemical engineers who are also ACS members, these latter being generally older and more experienced.

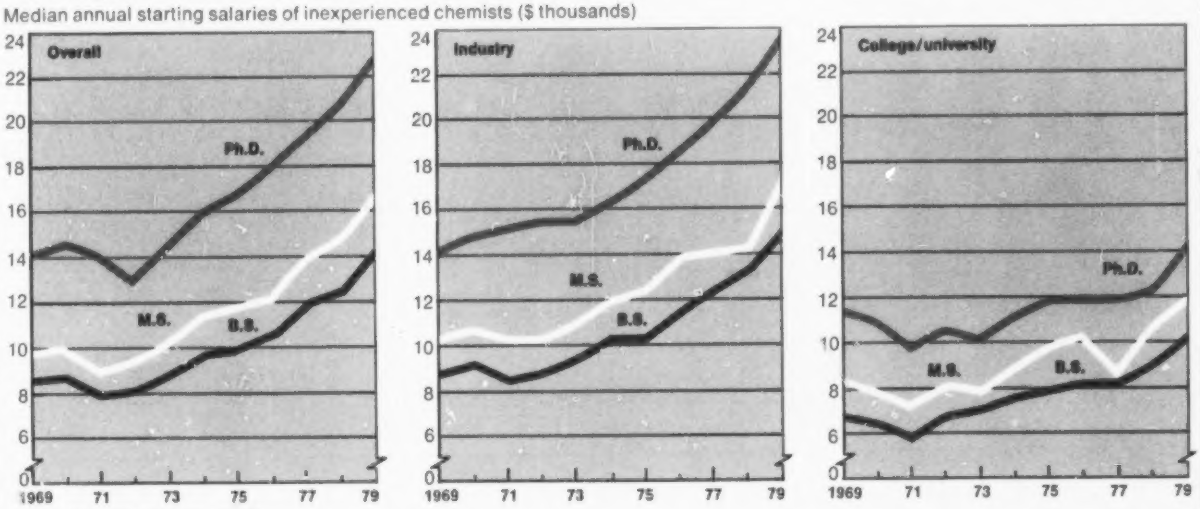
The median salary of all member chemists, whatever their degree, rose about 6% between March 1978 and March 1979. On the other hand, because of the 10% increase in the consumer price index during the same 12-month period, in constant dollars the median annual salary of chemists actually declined about 4%. This year's decrease in constant-dollar salaries is, in fact, the greatest since 1975.

Where chemists work affects their salaries. Among Ph.D. chemists, for example, the median salary in 1979 was $33,000 for those in manufacturing industry, $32,000 in the federal government, $27,600 in nonprofit organizations, $24,500 in public colleges and universities, and $23,000 in private colleges and universities.

Women chemists receive lower salaries than men who hold the same degrees and are doing the same types of jobs. One reason is the salary discrimination to which women long have been subjected in almost all professions, although this is now

Starting salaries this year rise at all degree levels

Median annual starting salaries of inexperienced chemists ($ thousands)



Source: ACS starting salary surveys

gradually being reduced. Another reason is that female chemists tend to be younger than male chemists and, therefore, less experienced. Female members of ACS who responded to its 1979 survey had a median age of 36, whereas male members had a median age of 44. In addition, women are less likely than men to work in higher-paying positions, such as management, but are more likely to work for universities and colleges, where salaries tend to be lower. Women also are less likely to have a Ph.D. degree. However, median salaries for women with B.S. degrees and less than four years of experience are higher than those of their male counterparts.

In 1979, the median salary of B.S. chemists was $25,000 for men and $17,500 for women. For M.S. chemists, the median salary was $26,000 for men and $19,500 for women. For Ph.D. chemists, it was $30,000 for men and $22,000 for women.

In industry in 1979, the median salary of B.S. chemists was $25,000 for men and $17,500 for women. The median for M.S. chemists in industry was $27,500 for men and $20,200 for women. For Ph.D. chemists, it was $33,000 for men and $26,400 for women.

The results of the 1979 ACS starting salary survey, which are based on replies from close to 4500 new chemistry and chemical engineering graduates, are reported here for the first time. They show that the median annual starting salary of inexperienced B.S. chemists working full time was $14,500, 14% above the $12,700 reported in 1978. The median starting salary of M.S. chemists climbed to $17,000, up 13% from $15,000 in 1978. In the same period, the median starting salary of Ph.D. chemists rose 10% from $21,000 to $23,000. These increases are decidedly greater than the 6 to 8% gains reported for the period between 1977 and 1978.

Characteristically, the median starting salaries of inexperienced chemical engineers are higher than those of chemists. The median starting salary of B.S. chemical engineers working full time, at $19,800 in 1979, was 9% higher than the $18,200 in 1978. In the same period, the median for M.S. chemical engineers rose 9% from $19,200 to $21,000. The median for Ph.D. chemical engineers increased 10% from $23,100 to $25,400.

The median starting salaries of full-time chemists and chemical engineers are influenced by their type of employer. In 1979, the medians for inexperienced full-time B.S. chemists were $15,000 for those in industry; $11,800 for those in federal, state, and local governments; $11,700 for those in hospitals, independent laboratories, and nonprofit organizations; and $10,300 for those in colleges and universities. The medians for inexperienced, full-time B.S. chemical engineers were $19,800 for those in industry; $18,000 for those in federal, state, and local governments; and $19,500 for those in hospitals, independent laboratories, and nonprofit organizations.

For the past several years, the median starting salaries of B.S. women chemists and chemical engineers in industry have been greater than those of their male counterparts. In 1979, the median for industrial B.S. chemists was $15,600 for women and $15,000 for men. The median for industrial B.S. chemical engineers was $20,000 for women and $19,800 for men. The higher initial salaries paid to women clearly reflect vigorous competition as companies, as part of their affirmative action programs, try to increase the number of women chemical professionals on their staffs.

Among inexperienced 1979 B.S. chemists, 28% are employed full time in the chemical profession. In addition, 30% are not seeking full-time employment (mainly because they are undertaking further studies), 24% hold graduate assistantships or fellowships, 9% are working outside the chemical profession, and 9% are unable to obtain full-time employment.

Among inexperienced 1979 Ph.D. chemists, 56% are employed full time in the chemical profession, 38% have postdoctoral fellowships, 4% are working outside the chemical profession, and 2% are unable to obtain full-time employment.

In recent years, the job outlook for new Ph.D. chemists has improved noticeably. This is reflected in the proportion of new Ph.D. chemists who are working full time in the chemical profession, which has risen from 44% in 1976 to 56% in 1979. Moreover, the proportion of new Ph.D.'s who undertake postdoctoral study, which some do because they cannot obtain other jobs, has declined from a high of 49% in 1976 to 38% this year.

Most new 1979 chemical engineers have full-time jobs in the chemical profession—72% of B.S. chemical engineers, 68% of M.S.'s, and 89% of Ph.D.'s. Those with full-time jobs outside the chemical profession constitute only 8% of B.S. and M.S. chemical engineers, 2% of Ph.D.'s. □

Salaries vary considerably with profession

Chemists' salaries have been rising. But how do they stack up against the earnings of other groups of professional workers?

Good, solid data gathered on an equivalent basis so that valid comparisons can be made are not generally available. Nevertheless, figures have been collected by various groups that at least give a clue to the level of earnings in various professions.

The American Medical Association reports, for example, that physicians had an average net income from their medical practice of about $63,000 in 1978. The American Dental Association finds that dentists' average net income from professional practice was about $50,000 during the same year. And according to the American Institute of Physics, the average salary of members (most of whom are physicists) of the societies of which it is composed, was about $27,500 last March.

The Bureau of Labor Statistics also gathers information on the average salaries for various white-collar occupations in private industry, largely to help set pay levels for federal employees. The resulting data (see accompanying table) permit some loose comparisons to be made between various professional and administrative occupations, at various levels of experience and job responsibility. BLS states, for example, that the figures it reports for mid-level chemists and engineers cover "fully experienced" employees, those for the top level cover only those employees responsible for "highly complex programs."

In general, the highest salaries for any profession surveyed by BLS are those earned by attorneys. (The figures cover only members of the bar working in the legal departments of industrial firms.) Engineers (of all types) and chemists are close behind.

	Average annual salary[a]
Attorneys, top level	$56,964
Chemists, top level	48,961
Chief accountants, top level	45,274
Engineers, top level	45,221
Personnel directors, top level	43,933
Accountants, top level	29,744
Engineers, mid-level	25,989
Chemists, mid-level	25,459
Personnel directors, starting	22,996
Attorneys, starting	18,740
Engineers, starting	17,345
Chemists, starting	14,455
Accountants, starting	13,790

[a] As of March 1979, excluding overtime and nonproduction bonuses. **Source:** Bureau of Labor Statistics

CAREER 1980 PLANNING

Career Planning is designed to familiarize both the student and the experienced graduate with services, sources of information, and organizations that can supply guidance in selecting, obtaining, and changing careers. The directory is a guide to U.S. organizations that employ significant numbers of chemists and chemical engineers. It is, of course, not all-inclusive. The directories listed under General Information, for instance, include the names of other organizations that employ chemists and chemical engineers. Inquiries about career opportunities in specific organizations should be addressed directly to the organization, in care of the personnel director.

GENERAL INFORMATION

American Chemical Society: *Chemical & Engineering News* salary surveys, employment surveys, and classified ads (see also ACS Information below), 1155—16th St., N.W., Washington, D.C. 20036.

Directories: "American Council of Independent Laboratories Directory, 1978," 1725 K St., N.W., Washington, D.C. 20006 (next edition will be published in 1980); "Association of Consulting Chemists & Chemical Engineers Council Directory," 20th edition, 1979, 50 East 41st St., New York, N.Y. 10017; "College Placement Annual, 1980," College Placement Council, P.O. Box 2263, Bethlehem, Pa. 18001; "American Consulting Engineers Council Membership Directory, 1979–80," 1155—15th St., N.W., Washington, D.C. 20005; "1979 Directory of Chemical Producers," SRI International, Menlo Park, Calif. 94025; "Industrial Research Laboratories of the United States," 16th edition, 1979, R. R. Bowker Co., 1180 Ave. of the Americas, New York, N.Y. 10036; "Research Centers Directory," 6th edition, 1979, Gale Research Co., Book Tower, Detroit, Mich. 48226.

Chemical Manufacturers Association: The brochures "Your Tomorrow—A Guide to Careers in the Chemical Industry" and "Minority Engineers in the Chemical Industry—A Guide to Career Selection" are available free from CMA's Publications Service, 1825 Connecticut Ave., N.W., Washington, D.C. 20009.

Scientific Manpower Commission: "Science and Engineering Careers—A Bibliography," April 1974, $2.00; "Salaries of Scientists, Engineers, and Technicians," 8th edition, October 1977, $15; "Salaries of Scientists, Engineers, and Technicians," 9th edition, October 1979, $20; "Professional Women and Minorities—A Manpower Data Resource Service," 1978, $75 (1979 supplement, $30); "Supply and Demand for Scientists and Engineers—A Review of Selected Studies," February 1977, $3.00; "Manpower Planning for Scientists and Engineers," May 1977, $2.00; *Manpower Comments*, 10 issues a year, $25 per year. All available from 1776 Massachusetts Ave., N.W., Washington, D.C. 20036.

Scientific and professional societies: American Institute of Chemists, 7315 Wisconsin Ave., Washington, D.C. 20014; American Institute of Chemical Engineers, 345 East 47th St., New York, N.Y. 10017; and National Society of Professional Engineers, 2029 K St., N.W., Washington, D.C. 20006. They offer information on their specific programs for career guidance and assistance.

Sources of information about prospective employers: Available in public libraries, "Moody's Industrial Manual," "Dun & Bradstreet," "Thomas Register of American Manufacturers," and "Standard and Poor's Register."

U.S. Department of Labor: Occupational Outlook Handbook, 1978–79 edition, Bulletin 1955, $8.00 per paperback copy. Order from Bureau of Labor Statistics, 1515 Broadway, New York, N.Y. 10036, or other regional office of BLS.

Vocational guidance manuals: "Opportunities in Chemistry" by John H. Woodburn, 1978; "Opportunities in Environmental Careers" by Odom Fanning, 1975; "Opportunities in Materials Science and Engineering" by Charles Wert, 1979; "Energy Careers" by John H. Woodburn, 1978; and "Chemical Engineering" by Joseph Haggerty, Earl Gerhard, and Charles Plank, 1978. Available from VGM Career Horizons, a division of National Textbook Co., 8259 Niles Center Rd., Skokie, Ill. 60077. "Encyclopedia of Careers and Vocational Guidance" by William E. Hopke, editor, 1978. Volume 1: "Planning Your Career." Volume 2: "Careers and Occupations." "Woman's Guide to Career Preparation" by Ann Jawin, 1979. Available from Doubleday & Co., 501 Franklin Ave, Garden City, N.Y. 11530.

ACS INFORMATION

Education aids for high school students: "Careers in Chemistry: Questions and Answers," "Chemical Technology Programs," "List of ACS Approved Schools," and "Financial Aids for College Students." All single copies free from ACS Special Issues Sales. *SciQuest*, published 10 times a year, $9.00 per year or $23 for three years. Group rates of 10 or more subscriptions entered with a single payment but mailed to different addresses, $6.50 each. Bulk subscriptions that are entered with a single payment for the school term and are mailed to one address, as low as $3.75 each, depending on the number of subscriptions ordered. Available from ACS Circulation Development Department, 1155—16th St., N.W., Washington, D.C. 20036.

Education aids for college students: "College Chemistry Seniors," a listing of résumés submitted by seniors majoring in chemistry and chemical engineering who plan to enter graduate school, 1979–80 edition, $30; "Directory of Graduate Research," a listing of Ph.D. degree-granting departments of chemistry, chemical engineering, biochemistry, and pharmaceutical/medicinal chemistry in the U.S. and Canada, with names of faculties, their research interests, and bibliographies of their recent publications, 1979 edition, $30;

and "College Chemistry Faculties," a listing of two- and four-year college and university teachers of chemistry, chemical engineering, and biochemistry in the U.S., Canada, and Mexico, fourth edition (1977), $15. All available from ACS Special Issues Sales. "Graduate School Information Aids," "Careers Nontraditional," and "Chemical Careers in the 1980's" are also available from ACS Special Issues Sales, single copy free. *Journal of Chemical Education*, a monthly publication of the ACS Division of Chemical Education, $12 per year for regular domestic subscribers and $9.00 per year for students. Available from *Journal of Chemical Education*, Subscription Fulfillment Department, 20th and Northampton St., Easton, Pa. 18042.

Continuing education aids: ACS Short Courses, live, intensive state-of-the-art courses in chemistry offered publicly year round, also available to organizations on an in-house basis; ACS Audio Courses, taped state-of-the-art courses by recognized authorities; ACS Film/Video Courses, chemistry lectures on 16-mm film and videotape; and ACS Interaction Courses, correspondence courses developed by experts and given by well-qualified instructors. All available from ACS Department of Educational Activities.

Employment information: "Professionals in Chemistry 1978," $11 to ACS members, $22 to nonmembers; "1979 Report of Chemists' Salaries and Employment Status," $10 to ACS members, $25 to nonmembers; "1978 Survey Report, Starting Salaries and Employment Status of Chemistry and Chemical Engineering Graduates," $2.00 to ACS members, $5.00 to nonmembers. All from ACS Special Issues Sales. The 1978 edition of "Professional Employment Guidelines" is free; send stamped, self-addressed, business-size envelope; "Chemistry: A Job or a Career?" consists of a 30-minute cassette tape, booklets, and a 30-mm slide presentation that are offered free to student affiliate chapters and to chemistry and chemical engineering departments. Available from ACS Department of Professional Relations & Manpower Studies.

Salary information in C&EN: Starting salaries in 1978, C&EN, Oct. 23, 1978, page 29. Comprehensive salary survey in 1979, C&EN, June 25, page 39.

ACS EMPLOYMENT AIDS

Employment Clearing House: ACS members and student affiliates in search of a new position can file applications in the Washington office at no charge. Employers may write or call the Washington office to receive copies of résumés of applicants who possess qualifications specified for the positions. The service is year-round and nonconfidential.

Confidential Employment Listing: This service enables employed ACS members who are seeking a new position to have their résumés on file at the ACS Employment Aids Office and to have them made available to all but certain specified employers, such as their present employer. This listing enables experienced candidates who otherwise would not wish to have their résumés circulated on a nonrestricted basis to let all but specified employers know of their desire to find a new position. Because of the added cost of handling such confidential records, ACS members are charged $25 a year for such a listing.

Employment Clearing House, National Meetings: The society aids ACS members and employers to arrange on-the-spot interviews at ACS national meetings. This free, nonconfidential service is open to those registered and in attendance at the meeting. Unemployed members may have registration fees waived on request.

Academic Openings: This publication lists positions, including postdoctoral positions, available at colleges and universities. It is published on a monthly basis if sufficient notices are received from academic institutions. The 20th of any month is the deadline for publication. If too few listings are received, publication is held over until the next month. This service is provided for all those interested in academic employment. Starting in January 1980, subscriptions to Academic Openings will cost $12 a year and can be obtained by writing to the ACS Employment Aids Office.

C&EN employment advertising section: Student affiliates and employed ACS members receive discounts from regular advertising rates. ACS members who are unemployed or are under notice of involuntary unemployment within 60 days may place one free classified "situations wanted" advertisement that will appear in every other issue for a period of six months—for a total of 13 insertions a year. Student members or student affiliates who have not gained employment two months before graduation are entitled to the same privileges. Retired members are entitled to six free nondisplay advertisements a year. See the Employment Ads Information box at the start of the C&EN employment advertising section for instructions.

Résumé service: An unemployed member may obtain free up to 50 printed copies of his or her résumé, limited to two pages typed in reproducible form. Write ACS Employment Aids Office.

ACS local sections: Some sections provide employment assistance. Contact the secretary of the local section.

For ACS information listed in this section, write to American Chemical Society, 1155—16th St., N.W., Washington, D.C. 20036.

OTHER EMPLOYMENT SERVICES

Classified listings: *Chemical & Engineering News*, weekly newsmagazine of the American Chemical Society; *Chemical Engineering Progress*, monthly magazine of the American Institute of Chemical Engineers; *The Chemist*, monthly publication of the American Institute of Chemists; *Science*, weekly magazine of the American Association for the Advancement of Science; and classified sections of newspapers.

College placement bureaus: Campus placement offices usually maintain a file of openings for graduating students and recent graduates. They frequently arrange interviews between students and employers.

Private placement agencies: Check those in your area to determine what services are offered. They differ widely in quality, cost, and nature of service.

State employment agencies: These organizations list openings for professional people without charge and also provide guidance on available government programs for retraining scientists and engineers.

U.S. Civil Service Commission: This agency maintains a listing of open examinations for jobs in government laboratories and other installations. Descriptions, locations, and salary information are available by writing to the commission at 1900 E St., N.W., Washington, D.C. 20415.

ORGANIZATIONS FOR WOMEN

American Association for the Advancement of Science: Office of Opportunities in Science, 1776 Massachusetts Ave., N.W., Washington, D.C. 20036; Women's Caucus, Phyllis Kahn, Member, Minnesota State Legislature, State Capitol, St. Paul, Minn. 55155.

American Association of University Professors: Committee on Status of Women in the Profession, AAUP, 1 Dupont Circle, N.W., Washington, D.C. 20036.

American Chemical Society: Women Chemists Committee, Wanda L. Brown, 212 Brightwood Pl., San Antonio, Tex. 78209

American Society of Biological Chemists: Committee on Equal Opportunities for Women, Elizabeth S. Maxwell, ASBC, 9650 Rockville Pike, Bethesda, Md. 20014.

Association for Women in Science: Room 1122, 1346 Connecticut Ave., N.W., Washington, D.C. 20036.

Sigma Delta Epsilon—Graduate Women in Science: Eltora Schroeder, SDE-GWS, Room 1102, 1346 Connecticut Ave., N.W., Washington, D.C. 20036.

Society of Women Engineers: Mary Lou Barnas, Executive Secretary, Room 305, 345 East 47th St., New York, N.Y. 10017.

Directory

The following list includes most of the nation's major employers of chemists and/or chemical engineers. The organizations did not ask to be included in this directory and are not necessarily hiring chemists or chemical engineers at this time.

Chemicals

Aceto Chemical Co., 126-02 Northern Blvd., Flushing, N.Y. 11368

Airco, 85 Chestnut Ridge Rd., Montvale, N.J. 07645 (subsidiary of BOC International Ltd. of the U.K.)

Air Products & Chemicals, P.O. Box 538, Allentown, Pa. 18105

Akzona, P.O. Box 2930, Asheville, N.C. 28802 (affiliated with Akzo N.V. of the Netherlands)

Alcolac, 3440 Fairfield Rd., Baltimore, Md. 21226

Aldrich Chemical Co., 940 West St. Paul Ave., Milwaukee, Wis. 53233

Allied Chemical Corp., P.O. Box 2245R, Morristown, N.J. 07960

American Color & Chemical Corp., P.O. Box 1688, Charlotte, N.C. 28232 (subsidiary of North American Philips Corp.)

American Cyanamid Co., 859 Berdan Ave., Wayne, N.J. 07470

American Enka Co., Enka, N.C. 28728 (division of Akzona)

American Hoechst Corp., Rte. 202-206 North, Somerville, N.J. 08876 (owned by Hoechst A.G. of West Germany)

American Hoechst Corp., industrial chemicals division, P.O. Box 268, Coventry, R.I. 02816

Amoco Chemicals Corp., 200 East Randolph Dr., Chicago, Ill. 60601 [subsidiary of Standard Oil Co. (Ind.)]

Ansul Co., 101 Stanton St., Marinette, Wis. 54143

Apex Chemical Co., 200 South First St., Elizabethport, N.J. 07206

Arco Chemical Co., 1500 Market St., Philadelphia, Pa. 19101 (division of Atlantic Richfield Co.)

Arizona Chemical Co., 859 Berdan Ave., Wayne, N.J. 07470 (affiliate of American Cyanamid Co. and International Paper Co.)

Armak Co., P.O. Box 1805, Chicago, Ill. 60690 (subsidiary of Akzona)

Ashland Chemical Co., P.O. Box 2219, Columbus, Ohio 43216 (division of Ashland Oil)

AZS Corp., P.O. Box 93366, Atlanta, Ga. 30318

Badische Corp., Williamsburg, Va. 23185 (member of BASF Group of West Germany)

J. T. Baker Chemical Co., 223 Red School Lane, Phillipsburg, N.J. 08865 (subsidiary of Richardson-Merrell)

BASF Wyandotte Corp., 100 Cherry Hill Rd., Parsippany, N.J. 07054 (owned by BASF A.G. of West Germany)

Beaunit Corp., 261 Madison Ave., New York, N.Y. 10016 (subsidiary of El Paso Natural Gas Co.)

Betz Laboratories, 4636 Somerton Rd., Trevose, Pa. 19047

Big Three Industries, P.O. Box 3047, Houston, Tex. 77001

Borden Chemical, 180 East Broad St., Columbus, Ohio 43215 (division of Borden)

Borg-Warner Corp., 200 South Michigan Ave., Chicago, Ill. 60604

Buckeye Cellulose Corp., P.O. Box 8407, Memphis, Tenn. 38108 (subsidiary of Procter & Gamble Co.)

Buckman Laboratories, 1256 North McLean Blvd., Memphis, Tenn. 38108

Cabot Corp., 125 High St., Boston, Mass. 02110

Calbiochem-Behring Corp., 10933 North Torrey Pines Rd., La Jolla, Calif. 92037 (subsidiary of American Hoechst Corp.)

Calgon Corp., P.O. Box 1346, Pittsburgh, Pa. 15230 (subsidiary of Merck & Co.)

Callery Chemical Co., Callery, Pa. 16024 (division of Mine Safety Appliances Co.)

Carus Corp., 1500 Eighth St., La Salle, Ill. 61301

Celanese Corp., 1211 Ave. of the Americas, New York, N.Y. 10036

CF Industries, Salem Lake Dr., Long Grove, Ill. 60047

Chemagro Agricultural division, P.O. Box 4913, Kansas City, Mo. 64120 (division of Mobay Chemical Corp.)

Chemed Corp., 1200 DuBois Tower, Cincinnati, Ohio 45202 (owned 90% by W. R. Grace & Co.)

Chemetron Corp., 111 East Wacker Dr., Chicago, Ill. 60601 (part of Allegheny Ludlum Industries)

Chemplex Co., 3100 Gold Rd., Rolling Meadows, Ill. 60008 (affiliate of American Can Co. and Getty Oil Co.)

Chevron Chemical Co., 575 Market St., San Francisco, Calif. 94105 (subsidiary of Standard Oil Co. of California)

Ciba-Geigy Corp., 444 Saw Mill River Rd., Ardsley, N.Y. 10502 (owned by Ciba-Geigy Ltd. of Switzerland)

Cincinnati Milacron, 4701 Marburg Ave., Cincinnati, Ohio 45209

City Chemical Corp., 134 West 22nd St., New York, N.Y. 10011

Clorox Co., 1221 Broadway, Oakland, Calif. 94612

Collier Carbon & Chemical Corp., P.O. Box 60455, Los Angeles, Calif. 90060 (subsidiary of Union Oil Co. of California)

Columbia Nitrogen Corp., P.O. Box 1483, Augusta, Ga. 30903 (owned by DSM of the Netherlands)

Conoco Chemicals, P.O. Box 2197, Houston, Tex. 77001 (division of Continental Oil Co.)

Cooperative Farm Chemical Association, P.O. Box 308, Lawrence, Kan. 66044

Copolymer Rubber & Chemical Corp., P.O. Box 2591, Baton Rouge, La. 70821

Crompton & Knowles Corp., dyes & chemicals division, Rte. 208, Fair Lawn, N.J. 07410

Cyclo Chemicals Corp., 7500 North West 66th St., Miami, Fla. 33166

Dart Industries, P.O. Box 3157, Terminal Annex, Los Angeles, Calif. 90051

Daubert Chemical Co., 1200 Jorie Blvd., Oak Brook, Ill. 60521

Dearborn Chemical, 300 Genesee St., Lake Zurich, Ill. 60047 (division of Chemed Corp.)

Detrex Chemical Industries, P.O. Box 501, Detroit, Mich. 48232

Dexter Chemical Corp., 845 Edgewater Rd., Bronx, N.Y. 10474

Dexter Corp., 1 Elm St., Windsor Locks, Conn. 06096

Diamond Shamrock Corp., 1100 Superior Ave., Cleveland, Ohio 44114

Diversey Corp., 100 West Monroe St., Chicago, Ill. 60603

Dixie Chemical Co., P.O. Box 13410, Houston, Tex. 77019

Dow Chemical U.S.A., 2020 Dow Ctr., Midland, Mich. 48640

Dow Corning Corp., P.O. Box 592, Midland, Mich. 48640 (jointly owned by Dow Chemical Co. and Corning Glass Works)

Drew Chemical Corp., 1 Drew Chemical Plaza, Boonton, N.J. 07005 (subsidiary of U.S. Filter Corp.)

DuBois Chemicals, 1314 DuBois Tower, Cincinnati, Ohio 45202 (division of Chemed Corp.)

E. I. du Pont de Nemours & Co., 1007 Market St., Wilmington, Del. 19898

Eagle-Picher Industries, 580 Walnut St., Cincinnati, Ohio 45202

Eastern Chemical division, P.O. Box 2500, Hauppauge, N.Y. 11787 (division of Guardian Chemical Corp.)

Eastman Chemical Products, P.O. Box 431, Kingsport, Tenn. 37662 (subsidiary of Eastman Kodak Co.)

Economics Laboratory, 370 Wabasha St., St. Paul, Minn. 55102

Emery Industries, 1300 Carew Tower, Cincinnati, Ohio 45202 (subsidiary of National Distillers & Chemical Corp.)

Emkay Chemical Co., 319-325 Second St., Elizabeth, N.J. 07206

Enserch Corp., 301 South Harwood St., Dallas, Tex. 75201

Essex Chemical Corp., 1401 Broad St., Clifton, N.J. 07015

Ethyl Corp., 330 South Fourth St., Richmond, Va. 23219

Exxon Chemical Co., 1251 Ave. of the Americas, New York, N.Y. 10020 (division of Exxon Corp.)

Fairmount Chemical Co., 117 Blanchard St., Newark, N.J. 07105

Farchan division, 4702 East 355th St., Willoughby, Ohio 44094 (division of Story Chemical Corp.)

Farmland Industries, P.O. Box 7305, Kansas City, Mo. 64116

Ferro Corp., 1 Erieview Plaza, Cleveland, Ohio 44114

Fiber Industries, Hwy. 70 West, Salisbury, N.C. 28144 (jointly owned by Celanese Corp. and Imperial Chemical Industries of the U.K.)

Filtrol Corp., 5959 West Century Blvd., Los Angeles, Calif. 90045 (subsidiary of U.S. Filter Corp.)

Firestone Plastics Co., P.O. Box 699, Pottstown, Pa., 19464 (division of Firestone Tire & Rubber Co.)

First Chemical Corp., P.O. Box 1427, Pascagoula, Miss. 39567 (subsidiary of First Mississippi Corp.)

Fisher Scientific Co., chemical manufacturing division, 711 Forbes Ave., Pittsburgh, Pa. 15219

FMC Corp., 200 East Randolph Dr., Chicago, Ill. 60601

FMC Corp., industrial chemical group, 2000 Market St., Philadelphia, Pa. 19103

Foster Grant Co., 289 North Main St., Leominster, Mass. 01453 (subsidiary of American Hoechst Corp.)

Fritzsche Dodge & Olcott, 76 Ninth Ave., New York, N.Y. 10011

GAF Corp., 140 West 51st St., New York, N.Y. 10020

General Electric Co., engineered materials group, 500 West Wilson Bridge Rd., Columbus, Ohio 43285

General Electric Co., plastics business division, 1 Plastics Ave., Pittsfield, Mass. 01201

General Latex & Chemical Corp., 666 Main St., Cambridge, Mass. 02139

General Tire & Rubber Co., chemical/plastics division, 1 General St., Akron, Ohio 44329

Georgia-Pacific Corp., 900 South West Fifth Ave., Portland, Ore. 97204

Givaudan Corp., 100 Delawanna Ave., Clifton, N.J. 07014

Glyco Chemicals, P.O. Box 700, Greenwich, Conn. 06830

B. F. Goodrich Chemical Co., 6100 Oak Tree Blvd., Cleveland, Ohio 44131 (division of B. F. Goodrich Co.)

Goodyear Tire & Rubber Co., chemical division, 1144 East Market St., Akron, Ohio 44316

W. R. Grace & Co., 1114 Ave. of the Americas, New York, N.Y. 10036

Great Lakes Carbon Corp., 299 Park Ave., New York, N.Y. 10017

Great Lakes Chemical Corp., P.O. Box 2200, West Lafayette, Ind. 47906

Great Salt Lake Minerals & Chemicals Corp., P.O. Box 1190, Ogden, Utah 84402 (subsidiary of Gulf Resources & Chemical Corp.)

Grow Chemical Corp., 345 Park Ave., New York, N.Y. 10022

GTE Sylvania, 1 Stamford Forum, Stamford, Conn. 06904 (subsidiary of General Telephone & Electronics Corp.)

Guardian Chemical Corp., 230 Marcus Blvd., Hauppauge, N.Y. 11787

Gulf Oil Chemicals Co., P.O. Box 3766, Houston, Tex. 77001 (division of Gulf Oil Corp.)

Hach Chemical Co., P.O. Box 389, Loveland, Colo. 80537

C. P. Hall Co., 7300 South Central Ave., Chicago, Ill. 60638

Harshaw Chemical Co., 1933 East 97th St., Cleveland, Ohio 44106 (subsidiary of Kewanee Industries)

Henkel Corp., 4620 West 77th St., Minneapolis, Minn. 55435 (subsidiary of Henkel of West Germany)

Hercules, 910 Market St., Wilmington, Del. 19899

Hilton-Davis Chemical Co., 2235 Langdon Farm Rd., Cincinnati, Ohio 45237 (division of Sterling Drug)

Hitco, 1600 West 135th St., Gardena, Calif. 90249 (subsidiary of Armco)

Hoechst Fibers Industries, 1515 Broadway, New York, N.Y. 10036 (division of American Hoechst Corp.)

Hooker Chemicals & Plastics Corp., 1034 Iroquois Ave., Niagara Falls, N.Y. 14302 (subsidiary of Occidental Petroleum Corp.)

Humko Sheffield Chemical, P.O. Box 398, Memphis, Tenn. 38101 (division of Kraft)

Humphrey Chemical Co., Devine St., North Haven, Conn. 06473

Philip A. Hunt Chemical Corp., P.O. Box 800, Palisades Park, N.J. 07650

ICI United States, Concord Pike & New Murphy Rd., Wilmington, Del. 19897 (owned by a subsidiary of Imperial Chemical Industries Ltd. of U.K.)

IMC Chemical Group, 666 Garland Pl., Des Plaines, Ill. 60016 (subsidiary of International Minerals & Chemical Corp.)

Inmont Corp., 1133 Ave. of the Americas, New York, N.Y. 10036

International Flavors & Fragrances, 521 West 57th St., New York, N.Y. 10019

International Minerals & Chemical Corp., Hwy. 45 and Winchester Rd., Libertyville, Ill. 60048

Jefferson Chemical Co., P.O. Box 430, Bellaire, Tex. 77401 (subsidiary of Texaco)

Kaiser Chemicals, 300 Lakeside Dr., Oakland, Calif. 94643 (division of Kaiser Aluminum & Chemical Corp.)

Kay-Fries, Stony Point, N.Y. 10980 (owned by Dynamit Nobel A.G. of West Germany)

Kerr-McGee Chemical Corp., Kerr-McGee Ctr., Oklahoma City, Okla. 73125 (subsidiary of Kerr-McGee Corp.)

Kewanee Industries, P.O. Box 591, Bryn Mawr, Pa. 19010 (subsidiary of Gulf Oil Corp.)

Koppers Co., 1420 Koppers Bldg., Pittsburgh, Pa. 15219

Lawter Chemicals, 990 Skokie Blvd., Northbrook, Ill. 60062

Liquid Air Corp. of North America, 405 Lexington Ave., New York, N.Y. 10017

Liquid Carbonic Corp., 135 South La Salle St., Chicago, Ill. 60603 (subsidiary of Houston Natural Gas Corp.)

Lithium Corp. of America, 449 North Cox Rd., Gastonia, N.C. 28052 (subsidiary of Gulf Resources & Chemical Corp.)

Lonza, 22-10 Rte. 208, Fair Lawn, N.J. 07410 (owned by Lonza Ltd. of Switzerland)

Lubrizol Corp., 29400 Lakeland Blvd., Wickliffe, Ohio 44092

Mackenzie Chemical Works, 1 Cordeilo Ave., Central Islip, N.Y. 11722

Mallinckrodt, P.O. Box 5840, St. Louis, Mo. 63134

MC&B Manufacturing Chemists, 2909 Highland Ave., Norwood, Ohio 45212 (division of G. D. Searle & Co.)

Millmaster Chemical Co., 99 Park Ave., New York, N.Y. 10016 (subsidiary of Kewanee Industries)

Mobay Chemical Corp., Penn Lincoln Pkwy. West, Pittsburgh, Pa. 15205 (owned by Bayer A.G. of West Germany)

Mobil Chemical Co., 150 East 42nd St., New York, N.Y. 10017 (division of Mobil Oil Corp.)

Monsanto Co., 800 North Lindbergh Blvd., St. Louis, Mo. 63166

Morton Chemical Co., 110 North Wacker Dr., Chicago, Ill. 60606 (division of Morton-Norwich Products)

M&T Chemicals, Woodbridge Rd. and Randolph Ave., Rahway, N.J. 07065 (wholly owned subsidiary of Société Nationale Elf Aquitaine)

Nalco Chemical Co., 2901 Butterfield Rd., Oak Brook, Ill. 60521

National Distillers & Chemical Corp., 99 Park Ave., New York, N.Y. 10016

National Starch & Chemical Corp., 10 Finderne Ave., Bridgewater, N.J. 08807 (owned by Unilever of the U.K.)

Neville Chemical Co., 1938 Neville Island, Pittsburgh, Pa. 15225

New England Nuclear Corp., 549 Albany St., Boston, Mass. 02118

NL Industries, industrial chemicals division, P.O. Box 700, Hightstown, N.J. 08520

Northern Petrochemical Co., 2350 East Devon Ave., Des Plaines, Ill. 60018 (subsidiary of Northern Natural Gas Co.)

Norton Chemical Process Products division, P.O. Box 350, Akron, Ohio 44309 (division of Norton Co.)

Noury Chemical Corp., Rte. 78, Burt, N.Y. 14028 (subsidiary of Armak Co.)

Novamont Corp., 1114 Ave. of the Americas, New York, N.Y. 10036 (subsidiary of Montedison, S.p.A. of Italy)

Occidental Chemical Co., 200[illegible] South Post Oak Rd., Houston, Tex. 77027 (subsidiary of Occidental Petroleum Corp.)

Olin Corp., 120 Long Ridge Rd., Stamford, Conn. 06904

Ott division, 500 Agard Rd., Muskegon, Mich. 49445 (division of Story Chemical Corp.)

Oxirane Corp., 4550 Post Oak Place Dr., Houston, Tex. 77027

Ozark-Mahoning Co., 1870 South Boulder Ave., Tulsa, Okla. 74119 (subsidiary of Pennwalt Corp.)

Pacific Resins & Chemicals. 1754 Thorne Rd., Tacoma, Wash. 98421 (subsidiary of Univar Corp.)

Pantasote Co., P.O. Box 1800, Greenwich, Conn. 06830

Pearsall Chemical Corp., P.O. Box 437, Houston, Tex. 77001

S. B. Penick & Co., 1050 Wall St. West, Lyndhurst, N.J. 07071 (unit of CPC International)

Pennwalt Corp., 3 Pkwy., Philadelphia, Pa. 19102

Petro-Tex Chemical Corp., 8600 Park Place Blvd., Houston, Tex. 77017 (affilate of FMC Corp. and Tenneco)

Pfanstiehl Laboratories, 1219 Glen Rock Ave., Waukegan, Ill. 60085

Pfister Chemical, Linden Ave., Ridgefield, N.J. 07657

Philadelphia Quartz Co., P.O. Box 840, Valley Forge, Pa. 19482

Phillips Fibers Corp., P.O. Box 66, Greenville, S.C. 29602 (jointly owned by Phillips Petroleum Co. and Rhône-Poulenc S.A. of France)

Pierce Chemical Co., P.O. Box 117, Rockford, Ill. 61105

PPG Industries, 1 Gateway Ctr., Pittsburgh, Pa. 15222

Publicker Industries, 1429 Walnut St., Philadelphia, Pa. 19102

PVO International, World Trade Ctr., San Francisco, Calif. 94111

Quaker Oats Co., chemicals division, P.O. Box 3514, Chicago, Ill. 60654

Reichhold Chemicals, 523 North Broadway, White Plains, N.Y. 10603

Reilly Tar & Chemical Corp., 151 North Delaware St., Indianapolis, Ind. 46204

Rexene Polyolefins Co., P.O. Box 37, Paramus, N.J. 07652 (subsidiary of Dart Industries)

Rhodia, 600 Madison Ave., New York, N.Y. 10022 (subsidiary of Rhône-Poulenc S.A. of France)

Richardson Co., 2400 East Devon Ave., Des Plaines, Ill. 60018

Rilsan Corp., 139 Harristown Rd., Glen Rock, N.J. 07452 (owned by ATO Chimie of France)

F. Ritter & Co., 4001 Goodwin Ave., Los Angeles, Calif. 90039

Rohm & Haas Co., Independence Mall West, Philadelphia, Pa. 19105

R.S.A. Corp., 690 Saw Mill River Rd., Ardsley, N.Y. 10502

Rubicon Chemicals, P.O. Box 517, Geismar, La. 70734 (affiliated with ICI and Uniroyal)

Sandoz, Rte. 10, East Hanover, N.J. 07936 (owned by Sandoz Ltd. of Switzerland)

SCM Corp., 299 Park Ave., New York, N.Y. 10017

Shell Chemical Co., P.O. Box 2463, Houston, Tex. 77001 (division of Shell Oil Co.)

Shepherd Chemical Co., 4900 Beech St., Cincinnati, Ohio 45212

Stauffer Chemical Co., Nyala Farm Rd., Westport, Conn. 06880

Stepan Chemical Co., Edens and Winnetka Rd., Northfield, Ill. 60093

Sterling Organics, 90 Park Ave., New York, N.Y. 10016 (division of Sterling Drug)

Story Chemical Corp., 500 Agard Rd., Muskegon, Mich. 49445

Sun Chemical Corp., 200 Park Ave., New York, N.Y. 10017

Sybron Corp., 1100 Midtown Tower, Rochester, N.Y. 14604

Tenneco Chemicals, Park 80 Plaza West, Saddle Brook, N.J. 07662 (division of Tenneco)

Thompson-Hayward Chemical Co., 5200 Speaker Rd., Kansas City, Kan. 66106 (subsidiary of North American Philips Corp.)

Toms River Chemical Corp., P.O. Box 71, Toms River, N.J. 08753 (jointly owned by Ciba-Geigy Corp. and Sandoz Ltd. of Switzerland)

Union Carbide Corp., 270 Park Ave., New York, N.Y. 10017

Union Chemicals, 1345 North Meacham Rd., Schaumburg, Ill. 60196 (division of Union Oil Co. of California)

Uniroyal Chemical Co., Spencer St., Naugatuck, Conn. 06770 (division of Uniroyal)

United Nuclear Corp., 7700 Leesburg Pike, Falls Church, Va. 22043

U.S. Borax & Chemical Corp., 3075 Wilshire Blvd., Los Angeles, Calif. 90010 (owned by Rio Tinto Zinc Corp. of U.K.)

U.S. Industrial Chemicals Co., 99 Park Ave., New York, N.Y. 10016 (division of National Distillers & Chemical Corp.)

USM Corp., 140 Federal St., Boston, Mass. 02112 (subsidiary of Emhart Corp.)

USS Chemicals, 600 Grant St., Pittsburgh, Pa. 15230 (division of U.S. Steel Corp.)

Vanderbilt Chemical Corp., 30 Winfield St., Norwalk, Conn. 06855 (subsidiary of R. T. Vanderbilt Co.)

Velsicol Chemical Corp., 341 East Ohio St., Chicago, Ill. 60611 (subsidiary of Northwest Industries)

Ventron Corp., Congress St., Beverly, Mass. 01915 (subsidiary of Thiokol Corp.)

Verona Dyestuff division, P.O. Box 385, Union, N.J. 07083 (division of Mobay Chemical Corp.)

Virginia Chemicals, 3340 West Norfolk Rd., Portsmouth, Va. 23703

Vistron Corp., Midland Bldg., Cleveland, Ohio 44115 [subsidiary of Standard Oil Co. (Ohio)]

Vulcan Materials Co., P.O. Box 7689, Birmingham, Ala. 35223

West Chemical Products, 42-16 West St., Long Island City, N.Y. 11101 (subsidiary of West Argo Chemicals)

Williams Cos., 320 South Boston Ave., Tulsa, Okla. 74103

Witco Chemical Corp., 277 Park Ave., New York, N.Y. 10017

Drugs

Abbott Laboratories, 1400 Sheridan Rd., North Chicago, Ill. 60064

American Home Products Corp., 685 Third Ave., New York, N.Y. 10017

Ames Co., P.O. Box 70, Elkhart, Ind. 46515 (division of Miles Laboratories)

Armour Pharmaceutical Co., P.O. Box 1849, Scottsdale, Ariz. 85252 (subsidiary of Revlon)

Ayerst Laboratories, 685 Third Ave., New York, N.Y. 10017 (division of American Home Products Corp.)

Baxter Travenol Laboratories, Baxter Pkwy., Deerfield, Ill. 60015

Breon Laboratories, 90 Park Ave., New York, N.Y. 10016 (subsidiary of Sterling Drug)

Bristol Laboratories, P.O. Box 657, Syracuse, N.Y. 13201 (division of Bristol-Myers Co.)

Bristol-Myers Co., 345 Park Ave., New York, N.Y. 10022

Burroughs Wellcome Co., 3030 Cornwallis Rd., Research Triangle Park, N.C. 27709 (owned by Wellcome Foundation Ltd. of U.K.)

Carter-Wallace, 767 Fifth Ave., New York, N.Y. 10022

Ciba-Geigy Corp., pharmaceuticals division, 556 Morris Ave., Summit, N.J. 07901 (owned by Ciba-Geigy Ltd. of Switzerland)

Cooper Laboratories, 1259 Rte. 46, Parsippany, N.J. 07054

Cutter Laboratories, Fourth and Parker St., Berkeley, Calif. 94710 (owned by Bayer A.G. of West Germany)

Dorsey Laboratories, P.O. Box 83288, Lincoln, Neb. 68501 (division of Sandoz)

Endo Laboratories, 1000 Stewart Ave., Garden City, N.Y. 11530 (subsidiary of Du Pont)

Ethicon, U.S. Hwy. 22, Somerville, N.J. 08876 (subsidiary of Johnson & Johnson)

Ganes Chemicals, 1114 Ave. of the Americas, New York, N.Y. 10036 (owned by Siegfried Ltd. of Switzerland)

Hoechst-Roussel Pharmaceuticals, Rte. 202-206 North, Somerville, N.J. 08876 (subsidiary of American Hoechst Corp.)

Hoffmann-La Roche, 340 Kingsland Rd., Nutley, N.J. 07110 (member of Hoffmann-La Roche Group of Switzerland)

ICN Pharmaceuticals, 2727 Campus Dr., Irvine, Calif. 92664

Inolex Pharmaceutical, 2600 Bond St., Park Forest South, Ill. 60466 (division of Inolex Corp.)

Directory

Lederle Laboratories, North Middletown Rd., Pearl River, N.Y. 10965 (division of American Cyanamid Co.)

Eli Lilly & Co., 307 East McCarty St., Indianapolis, Ind. 46206

Marion Laboratories, 10236 Bunker Ridge Rd., Kansas City, Mo. 64137

McNeil Laboratories, Camp Hill Rd., Fort Washington, Pa. 19034 (subsidiary of Johnson & Johnson)

Mead Johnson & Co., 2400 Pennsylvania St., Evansville, Ind. 47721 (subsidiary of Bristol-Myers Co.)

Merck & Co., P.O. Box 2000, Rahway, N.J. 07065

Merrell-National Laboratories, 110 East Amity Rd., Cincinnati, Ohio 45215 (division of Richardson-Merrell)

Miles Laboratories, P.O. Box 40, Elkhart, Ind. 46515 (owned by Bayer A.G. of West Germany)

Morton-Norwich Products, 110 North Wacker Dr., Chicago, Ill. 60606

Norwich-Eaton Pharmaceuticals, 17 Eaton Ave., Norwich, N.Y. 13815 (division of Morton-Norwich Products)

Organon, 375 Mt. Pleasant Ave., West Orange, N.J. 07052 (subsidiary of Akzona)

Ortho Pharmaceutical Corp., Raritan, N.J. 08869 (subsidiary of Johnson & Johnson)

Parke, Davis & Co., P.O. Box 118, G.P.O., Detroit, Mich. 48232 (subsidiary of Warner-Lambert Co.)

Pfizer, 235 East 42nd St., New York, N.Y. 10017

Philips Roxane Laboratories, 330 Oak St., Columbus, Ohio 43216 (subsidiary of North American Philips Corp.)

Purdue Frederick Co., 50 Washington St., Norwalk, Conn. 06856

Rachelle Laboratories, 700 Henry Ford Ave., Long Beach, Calif. 90801

Richardson-Merrell, 10 Westport Rd., Wilton, Conn. 06897

Riker Laboratories, 19901 Nordhoff St., Northridge, Calif. 91324 (subsidiary of 3M Co.)

A. H. Robins Co., 1407 Cummings Dr., Richmond, Va. 23220

Wm. H. Rorer, 500 Virginia Dr., Fort Washington, Pa. 19034 (subsidiary of Rorer Group)

Sandoz Pharmaceuticals, Rte. 10, East Hanover, N.J. 07936 (division of Sandoz)

R. P. Scherer Corp., 9425 Grinnell Ave., Detroit, Mich. 48213

Schering-Plough Corp., Galloping Hill Rd., Kenilworth, N.J. 07033

G. D. Searle & Co., P.O. Box 1045, Skokie, Ill. 60076

SmithKline Corp., 1500 Spring Garden St., Philadelphia, Pa. 19101

E. R. Squibb & Sons, P.O. Box 4000, Princeton, N.J. 08540 (subsidiary of Squibb Corp.)

Sterling Drug, 90 Park Ave., New York, N.Y. 10016

Stuart Pharmaceuticals, 3411 Silverside Rd., Wilmington, Del. 19897 (division of ICI United States)

Syntex Laboratories, 3401 Hillview Ave., Palo Alto, Calif. 94304

Upjohn Co., 7000 Portage Rd., Kalamazoo, Mich. 49001

USV Laboratories, 1 Scarsdale Rd., Tuckahoe, N.Y. 10707 (division of Revlon)

Wallace Laboratories, Half Acre Rd., Cranbury, N.J. 08512 (division of Carter-Wallace)

Warner-Lambert Co., 201 Tabor Rd., Morris Plains, N.J. 07950

Westwood Pharmaceuticals, 468 Dewitt St., Buffalo, N.Y. 14213

Winthrop Laboratories, 90 Park Ave., New York, N.Y. 10016 (division of Sterling Drug)

Wyeth Laboratories, P.O. Box 8299, Philadelphia, Pa. 19101 (division of American Home Products Corp.)

Personal-care products

Alberto Culver Co., 2525 Armitage Ave., Melrose Park, Ill. 60160

Avon Products, 9 West 57th St., New York, N.Y. 10019

Chesebrough-Ponds, 33 Benedict Pl., Greenwich, Conn. 06830

Clairol, 345 Park Ave., New York, N.Y. 10022 (subsidiary of Bristol-Myers Co.)

Colgate-Palmolive Co., 300 Park Ave., New York, N.Y. 10022

Fabergé, 310 East 44th St., New York, N.Y. 10019

Max Factor & Co., 1655 McCadden Pl., Hollywood, Calif. 90028 (subsidiary of Norton Simon)

Gillette Co., Prudential Tower Bldg., Boston, Mass. 02199

Andrew Jergens Co., 2535 Spring Grove Ave., Cincinnati, Ohio 45214 (subsidiary of American Brands)

Lever Brothers Co., 390 Park Ave., New York, N.Y. 10022 (owned by Unilever of the U.K.)

Noxell Corp., P.O. Box 1799, Baltimore, Md. 21203

Procter & Gamble Co., P.O. Box 599, Cincinnati, Ohio 452[illegible]

Purex Corp., 5101 Clark Ave., Lakewood, Calif. 90712

Revlon, 767 Fifth Ave., New York, N.Y. 10022

Shulton, 697 U.S. Hwy. 46, Clifton, N.J. 07015 (subsidiary of American Cyanamid Co.)

Coatings

Baltimore Paint & Chemical Corp., 2325 Hollins Ferry Rd., Baltimore, Md. 21230 (subsidiary of ELT)

Carboline Co., 350 Hanley Industrial Court, St. Louis, Mo. 63144

Cook Paint & Varnish Co., 1412 Knox St., North Kansas City, Mo. 64116

DeSoto, 1700 South Mt. Prospect Rd., Des Plaines, Ill. 60018

Dutch Boy, 500 Central Ave., Northfield, Ill. 60093

Glidden Coatings & Resins, 900 Union Commerce Tower, Cleveland, Ohio 44115 (division of SCM Corp.)

Guardsman Chemicals, 1350 Steele Ave., Southwest, Grand Rapids, Mich. 49507

Lilly Industrial Coatings, 666 South California St., Indianapolis, Ind. 46225

Benjamin Moore & Co., 51 Chestnut Ridge Rd., Montvale, N.J. 07645

O'Brien Corp., P.O. Box 4037, South Bend, Ind. 46634

Porter Paint Co., 13th and Walnut St., Louisville, Ky. 40201

Pratt & Lambert, P.O. Box 22, Buffalo, N.Y. 14240

Sherwin-Williams Co., 101 Prospect Ave., N.W., Cleveland, Ohio 44101

Valspar Corp., 1101 Third St. South, Minneapolis, Minn. 55415

Petroleum

Amerada Hess Corp., 1 Hess Plaza, Woodbridge, N.J. 07095

American Petrofina, P.O. Box 2159, Dallas, Tex. 75221

Ashland Oil, P.O. Box 391, Ashland, Ky. 41101

Atlantic Richfield Co., 515 South Flower St., Los Angeles, Calif. 90071

Cities Service Co., 110 West Seventh St., Tulsa, Okla. 74102

Clark Oil & Refining Corp., 8530 West National Ave., Milwaukee, Wis. 53201

Continental Oil Co., High Ridge Park, Stamford, Conn. 06904

Cosden Oil & Chemical Co., P.O. Box 1311, Big Spring, Tex. 79720 (subsidiary of American Petrofina)

Exxon Corp., 1251 Ave. of the Americas, New York, N.Y. 10020

Getty Oil Co., 3810 Wilshire Blvd., Los Angeles, Calif. 90010

Gulf Oil Corp., Gulf Bldg., Pittsburgh, Pa. 15219

Kerr-McGee Corp., Kerr-McGee Ctr., Oklahoma City, Okla. 73125

Marathon Oil Co., 539 South Main St., Findlay, Ohio 45840

Mobil Oil Corp., 150 East 42nd St., New York, N.Y. 10017

Murphy Oil Corp., 200 Jefferson Ave., El Dorado, Ark. 71730

Occidental Petroleum Corp., 10889 Wilshire Blvd., Los Angeles, Calif. 90024

Pennzoil Co., 900 Southwest Tower, Houston, Tex. 77002

Phillips Petroleum Co., Phillips Bldg., Bartlesville, Okla. 74004

Quaker State Oil Refining Corp., P.O. Box 989, Oil City, Pa. 16301

Shell Oil Co., 1 Shell Plaza, Houston, Tex. 77002

Standard Oil Co. of California, 225 Bush St., San Francisco, Calif. 94104

Standard Oil Co. (Ind.), 200 East Randolph Dr., Chicago, Ill. 60680

Standard Oil Co. (Ohio), Midland Bldg., Cleveland, Ohio 44115

Sun Co., 100 Matsonford Rd., Radnor, Pa. 19807

Tenneco, P.O. Box 2511, Houston, Tex. 77001

Texaco, 2000 Westchester Ave., White Plains, N.Y. 10650

Union Oil Co. of California, Union Oil Ctr., Los Angeles, Calif. 90017

Rubber

American Biltrite, 575 Technology Sq., Cambridge, Mass. 02139

Amstrong Rubber Co., 500 Sargent Dr., New Haven, Conn. 06507

Carlisle Corp., 511 Walnut St., Cincinnati, Ohio 45202

Cooper Tire & Rubber Co., Lima and Western Ave., Findlay, Ohio 45840

Firestone Tire & Rubber Co., 1200 Firestone Pkwy., Akron, Ohio 44317

Gates Rubber Co., 999 South Broadway, Denver, Colo. 80217

General Tire & Rubber Co., 1 General St., Akron, Ohio 44329

B. F. Goodrich Co., 500 South Main St., Akron, Ohio 44318

Goodyear Tire & Rubber Co., 1144 East Market St., Akron, Ohio 44316

Mohawk Rubber Co., 50 Executive Pkwy., Hudson, Ohio 44236

St. Clair Rubber Co., 107 Clifford St., Detroit, Mich. 48226

Uniroyal, 1230 Ave. of the Americas, New York, N.Y. 10020

Paper and forest products

Bemis Co., 800 Northstar Ctr., Minneapolis, Minn. 55402

Boise Cascade Corp., P.O. Box 50, Boise, Idaho 83728

Champion International Corp., 1 Landmark Sq., Stamford, Conn. 06921

Charmin Paper Products Co., 800 University Ave., Green Bay, Wis. 54302 (subsidiary of Procter & Gamble Co.)

Consolidated Papers, First Ave. North, Wisconsin Rapids, Wis. 54494

Container Corp. of America, 1 First National Plaza, Chicago, Ill. 60670 (subsidiary of Marcor)

Continental Forest Industries, Greenwich Office Park 2, Greenwich, Conn. 06830 (member of Continental Group)

Crown Zellerbach Corp., 1 Bush St., San Francisco, Calif. 94119

Diamond International Corp., 733 Third Ave., New York, N.Y. 10017

Georgia-Pacific Corp., 900 Southwest Fifth Ave., Portland, Ore. 97204

Great Northern Nekoosa Corp., 75 Prospect St., Stamford, Conn. 06901

Hammermill Paper Co., 1442 East Lake Rd., Erie, Pa. 16533

Inland Container Corp., 151 North Delaware St., Indianapolis, Ind. 46206

International Paper Co., 220 East 42nd St., New York, N.Y. 10017

ITT Rayonier, 605 Third Ave. New York, N.Y. 10016 (subsidiary of International Telephone & Telegraph Corp.)

Kimberly-Clark Corp., 128 North Lake St., Neenah, Wis. 54956

Mead Corp., Courthouse Plaza Northeast, Dayton, Ohio 45463

Potlatch Corp., 1 Maritime Plaza, San Francisco, Calif. 94111

St. Regis Paper Co., 150 East 42nd St., New York, N.Y. 10017

Scott Paper Co., Scott Plaza, Philadelphia, Pa. 19113

Union Camp Corp., 1600 Valley Rd., Wayne, N.J. 07470

Westvaco Corp., 299 Park Ave., New York, N.Y. 10017

Weyerhaeuser Co., Tacoma, Wash. 98401

Metals and minerals

Allegheny Ludlum Industries, Oliver Bldg., Mellon Sq., Pittsburgh, Pa. 15222

Allied-Kelite Products division, 2400 East Devon Ave., Des Plaines, Ill. 60018 (division of Richardson Co.)

Aluminum Co. of America, 1126 Alcoa Bldg., Pittsburgh, Pa. 15219

Amax, Amax Ctr., Greenwich, Conn. 06830

Anaconda Co., 1271 Ave. of the Americas, New York, N.Y. 10020 (subsidiary of Atlantic Richfield Co.)

Armco, P.O. Box 600, Middletown, Ohio 45043

Asarco, 120 Broadway, New York, N.Y. 10005

Basic Chemicals, 845 Hanna Bldg., Cleveland, Ohio 44115 (division of Basic)

Bethlehem Steel Corp., 701 East Third St., Bethlehem, Pa. 18016

Carpenter Technology Corp., 150 West Bern St., Reading, Pa. 19603

Cerro Metal Products, P.O. Box 388, Bellefonte, Pa. 16823 (division of Marmon Group)

Chromalloy American Corp., 120 South Central Ave., St. Louis, Mo. 63105

Climax Molybdenum Co., 1 Greenwich Plaza, Greenwich, Conn. 06830 (division of Amax)

Colt Industries, 430 Park Ave., New York, N.Y. 10022

Copperweld Bimetallics division, 100 Ninth St., Glassport, Pa. 15045 (division of Copperweld Corp.)

Cyclops Corp., 650 Washington Rd., Pittsburgh, Pa. 15228

Duval Corp., P.O. Box 2967, Houston, Tex. 77001 (subsidiary of Pennzoil Co.)

Engelhard Minerals & Chemicals Corp., 70 Wood Ave. South, Iselin, N.J. 08830

Fansteel, 1 Tantalum Pl., North Chicago, Ill. 60064

Foote Mineral Co., Rte. 100, Exton, Pa. 19341

Freeport Minerals Co., 161 East 42nd St., New York, N.Y. 10017

Gulf Resources & Chemical Corp., 1100 Milam Bldg., Houston, Tex. 77002

Handy & Harman, 850 Third Ave., New York, N.Y. 10022

Howmet Aluminum Corp., 475 Steamboat Rd., Greenwich, Conn. 06830 (affiliate of Péchiney Ugine of France)

Inland Steel Co., 30 West Monroe St., Chicago, Ill. 60603

Interlake, 135th St. and Perry Ave., Chicago, Ill. 60027

International Nickel Co., 1 New York Plaza, New York, N.Y. 10004

Jones & Laughlin Steel Corp., 3 Gateway Ctr., Pittsburgh, Pa. 15263 (owned by LTV Corp.)

Kaiser Aluminum & Chemical Corp., 300 Lakeside Dr., Oakland, Calif. 94643

Kaiser Steel Corp., 300 Lakeside Dr., Oakland, Calif. 94643 (affiliate of Kaiser Industries Corp.)

Kawecki Berylco Industries, 220 East 42nd St., New York, N.Y. 10017

Kennametal, P.O. Box 346, Latrobe, Pa. 15650

Kennecott Copper Corp., 161 East 42nd St., New York, N.Y. 10017

Martin Marietta Aluminum, 6801 Rockledge Dr., Bethesda, Md. 20034 (subsidiary of Martin Marietta Corp.)

Matthey Bishop, 4 Malin Rd., Malvern, Pa. 19355 (affiliate of Johnson Matthey & Co. of the U.K.)

McLouth Steel Corp., 300 South Livernois Ave., Detroit, Mich. 48209

Molycorp, 6 Corporate Park Dr., White Plains, N.Y. 10604 (affiliate of Union Oil Co. of California)

National Steel Corp., 2800 Grant Bldg., Pittsburgh, Pa. 15219

New Jersey Zinc Co., 2 University Plaza, Hackensack, N.J. 07601 (division of Gulf & Western Industries)

Phelps Dodge Refining Corp., P.O. Box 1126, Wall St. Station, New York, N.Y. 10005 (subsidiary of Phelps Dodge Corp.)

Republic Steel Corp., P.O. Box 6778, Cleveland, Ohio 44101

Revere Copper & Brass, 605 Third Ave., New York, N.Y. 10016

Reynolds Metals Co., P.O. Box 27003, Richmond, Va. 23261

St. Joe Minerals Corp., 250 Park Ave., New York, N.Y. 10017

Teledyne Wah Chang Albany, P.O. Box 460, Albany, Ore. 97321 (subsidiary of Teledyne)

Texasgulf, High Ridge Park, Stamford, Conn. 06904

Titanium Metals Corp. of America, P.O. Box 2824, Pittsburgh, Pa. 15230

United States Steel Corp., 600 Grant St., Pittsburgh, Pa. 15230

Food

American Maize-Products Co., 113th St. and Indianapolis Blvd., Hammond, Ind. 46326

Amstar Corp., 1251 Ave. of the Americas, New York, N.Y. 10020

Anderson Clayton Foods, P.O. Box 6165, Dallas, Tex. 75222 (division of Anderson Clayton & Co.)

Archer Daniels Midland Co., P.O. Box 1470, Decatur, Ill. 62525

Armour & Co., Greyhound Tower, Phoenix, Ariz. 85077 (subsidiary of Greyhound Corp.)

Beatrice Foods Co., 120 South La Salle St., Chicago, Ill. 60603

Borden, 180 East Broad St., Columbus, Ohio 43215.

Campbell Soup Co., Campbell Pl., Camden, N.J. 08101

Carnation Co., 5045 Wilshire Blvd., Los Angeles, Calif. 90036

Central Soya Co., 1300 Ft. Wayne National Bank Bldg., Ft. Wayne, Ind. 46802

Consolidated Foods Corp., 135 South La Salle St., Chicago, Ill. 60603

CPC International, International Plaza, Englewood Cliffs, N.J. 07632

Cudahy Co., 100 West Clarendon St., Phoenix, Ariz. 85013 (subsidiary of General Host Corp.)

Del Monte Corp., P.O. Box 3575, San Francisco, Calif. 94119

Esmark, 55 East Monroe St., Chicago, Ill. 60603

General Foods Corp., 250 North St., White Plains, N.Y. 10625

General Mills, P.O. Box 1113, Minneapolis, Minn. 55440

Gerber Products Co., Fremont, Mich. 49412

Heinz U.S.A., P.O. Box 57, Pittsburgh, Pa. 15230

Hershey Foods Corp., 19 East Chocolate Ave., Hershey, Pa. 17033

Geo. A. Hormel & Co., Austin, Minn. 55912

Kellogg Co., 235 Porter St., Battle Creek, Mich. 49016

Kraft, Kraft Court, Glenview, Ill. 60025

Libby, McNeill & Libby, 200 South Michigan Ave., Chicago, Ill. 60604

Thomas J. Lipton, 800 Sylvan Ave., Englewood Cliffs, N.J. 07632

McCormick & Co., 11350 McCormick Rd., Hunt Valley, Md. 21031

Nabisco, River Rd., East Hanover, N.J. 07936

Norton Simon, 277 Park Ave., New York, N.Y. 10017

Pepperidge Farm, P.O. Box 5500, Norwalk, Conn. 06856 (subsidiary of Campbell Soup Co.)

Pet, 400 South Fourth St., St. Louis, Mo. 63166

Pillsbury Co., 608 Second Ave., South, Minneapolis, Minn. 55402

Quaker Oats Co., P.O. Box 3514, Chicago, Ill. 60654

Ralston Purina Co., 835 South Eighth St., St. Louis, Mo. 63188

A. E. Staley Mfg. Co., P.O. Box 151, Decatur, Ill. 62525

Standard Brands, 625 Madison Ave., New York, N.Y. 10022

Stokely-Van Camp, 941 North Meridan St., Indianapolis, Ind. 46206

Swift & Co., 115 West Jackson Blvd., Chicago, Ill. 60604 (subsidiary of Esmark)

Universal Foods Corp., 433 East Michigan St., Milwaukee, Wis. 53201

Wm. Wrigley Jr. Co., 410 North Michigan Ave., Chicago, Ill. 60611

Other manufacturers

Abcor, 850 Main St., Wilmington, Mass. 01887

Addressograph Multigraph Corp., 1900 Ave. of the Stars, Los Angeles, Calif. 90067

Aerojet-General Corp., 9100 East Flair Dr., El Monte, Calif. 91734 (subsidiary of General Tire & Rubber Co.)

Allis-Chalmers Corp., P.O. Box 512, Milwaukee, Wis. 53201

Alza Corp., 950 Page Mill Rd., Palo Alto, Calif. 94304

American Air Filter Co., 200 Central Ave., Louisville, Ky. 40277

American Brands, 245 Park Ave., New York, N.Y. 10017

American Can Co., American Lane, Greenwich, Conn. 06830

American Hospital Supply Corp., 1740 Ridge Ave., Evanston, Ill. 60204

American Motors Corp., 14250 Plymouth Rd., Detroit, Mich. 48232

American Optical Corp., 14 Mechanic St., Southbridge, Mass. 01550 (subsidiary of Warner-Lambert Co.)

American Standard, 40 West 40th St., New York, N.Y. 10018

American Telephone & Telegraph Co., 195 Broadway, New York, N.Y. 10007

AMF World Tobacco Group, 689 Hope St., Stamford, Conn. 06907

AMP, P.O. Box 3608, Harrisburg, Pa. 17105

Ampex Corp., 401 Broadway, Redwood City, Calif. 94063

Analabs, 82 Republic Dr., North Haven, Conn. 06473 (subsidiary of New England Nuclear Corp.)

Anchor Hocking Corp., 70 Glass Ave., Lancaster, Ohio 43130

Anheuser-Busch, 721 Pestalozzi St., St. Louis, Mo. 63118

Armstrong Cork Co., 1010 Concord St., Lancaster, Pa. 17604

Atlantic Research Corp., 5390 Cherokee Ave., Alexandria, Va. 22314

Avco Corp., 1275 King St., Greenwich, Conn. 06830

Babcock & Wilcox Co., P.O. Box 1126, Wall St. Station, New York, N.Y. 10017

Badger Co., 1 Broadway, Cambridge, Mass. 02142 (division of Raytheon Co.)

Baird-Atomic, 125 Middlesex Tpke., Bedford, Mass. 01730

Bausch & Lomb, 1 Lincoln First Sq., Rochester, N.Y. 14601

Beckman Instruments, 2500 Harbor Blvd., Fullerton, Calif. 92634

Becton, Dickinson & Co., Rutherford, N.J. 07070

Bell & Howell Co., 7100 McCormick Rd., Chicago, Ill. 60645

Bendix Corp., Bendix Ctr., Southfield, Mich. 48076.

Bio-Dynamics, 9115 Hague Rd., Indianapolis, Ind. 46250

Blaw-Knox Co., 1 Oliver Plaza, Pittsburgh, Pa. 15222 (division of White Consolidated Industries)

Borg-Warner Corp., 200 South Michigan Ave., Chicago, Ill. 60604

Bostik, Middleton, Mass. 01949 (division of USM Corp.)

Bruning, 1834 Walden Office Sq., Schaumburg, Ill. 60196 (division of Addressograph Multigraph Corp.)

Budd Co., 3155 West Big Beaver Rd., Troy, Mich. 48084

Burlington Industries, P.O. Box 21207, Greensboro, N.C. 27420

Burroughs Corp., Burroughs Pl., Detroit, Mich. 48232

Carborundum Co., P.O. Box 337, Niagara Falls, N.Y. 14302 (subsidiary of Kennecott Copper Corp.)

Cargill, Cargill Bldg., Minneapolis, Minn. 55402

Caterpillar Tractor Co., 100 N.E. Adams St., Peoria, Ill. 61629

Celotex Corp., 1500 North Dale Mabry Hwy., Tampa, Fla. 33607 (division of Jim Walter Corp.)

Chemical Construction Corp., 1 Penn Plaza, New York, N.Y. 10001 (division of Aerojet-General Corp.)

Chemical Products Corp., P.O. Box 449, Cartersville, Ga. 30120

Chrysler Corp., P.O. Box 1919, Detroit, Mich. 48288

C&I Girdler, P.O. Box 32940, Louisville, Ky. 40232 (division of Bechtel Corp.)

Combustion Engineering, 900 Long Ridge Rd., Stamford, Conn. 06902

Continental Can Co. U.S.A., 5745 East River Rd., Chicago, Ill. 60631 (member of Continental Group)

Coors Porcelain Co., 600 Ninth St., Golden, Colo. 80401 (division of Adolph Coors Co.)

Corning Glass Works, 80 Houghton Park, Corning, N.Y. 14830

Crown Cork & Seal Co., 9300 Ashton Rd., Philadelphia, Pa. 19136

Curtiss-Wright Corp., 1 Passaic St., Wood-Ridge, N.J. 07075

Dade division, 1851 Delaware Pkwy., Miami, Fla. 33152 (division of American Hospital Supply Corp.)

Dan River International Corp., 111 West 40th St., New York, N.Y. 10018

Dayco Corp., 333 West First St., Dayton, Ohio 45402

Deere & Co., John Deere Rd., Moline, Ill. 61265

Dorr-Oliver, 77 Havemeyer La., Stamford, Conn. 06904 (subsidiary of Curtiss-Wright Corp.)

Dresser Industries, 1505 Elm St., Dallas, Tex. 75201

Eastman Kodak Co., 343 State St., Rochester, N.Y. 14650

El Paso Co., P.O. Box 2185, Houston, Tex. 77001

ESB, 5 Penn Ctr. Plaza, Philadelphia, Pa. 19103

Evans Products Co., P.O. Box 3295, Portland, Ore. 97208

Fairchild Camera & Instrument Corp., 464 Ellis St., Mountain View, Calif. 94042

Fasson, 252 Chester St., Painesville, Ohio 44077 (division of Avery International Co.)

Fisher Scientific Co., 711 Forbes Ave., Pittsburgh, Pa. 15219

Flintkote Co., 1351 Washington Blvd., Stamford, Conn. 06902

Fluor Corp., 2500 South Atlantic Blvd., Los Angeles, Calif. 90040

Ford, Bacon & Davis, 2 Broadway, New York, N.Y. 10004

Ford Motor Co., American Rd., Dearborn, Mich. 48127

Foremost-McKesson, 1 Post St., San Francisco, Calif. 94104

Directory

Foster Wheeler Corp., 110 South Orange Ave., Livingston, N.J. 07039
Foxboro Co., 86 Neponset Ave., Foxboro, Mass. 02035
Franklin GNO Corp., P.O. Box 3206, West Palm Beach, Fla. 33402
H. B. Fuller Co., 2400 Kasota Ave., St. Paul, Minn. 55108
GATX Corp., 120 South Riverside Plaza, Chicago, Ill. 60606
General Dynamics Corp., Pierre Laclede Ctr., St. Louis, Mo. 63105
General Electric Co., 1 River Rd., Schenectady, N.Y. 12345
General Motors Corp., 3044 West Grand Blvd., Detroit, Mich. 48202
General Resource Corp., 201 Third St. South, Hopkins, Minn. 55343
General Telephone & Electronics Corp., 1 Stamford Forum, Stamford, Conn. 06904
Globe-Union, 5757 North Green Bay Ave., Milwaukee, Wis. 53201
Grain Processing Corp., P.O. Box 341, Muscatine, Iowa 52761
Greyhound Corp., 111 West Clarendon Ave., Pheonix, Ariz. 85013
Grumman Corp., 1111 Stewart Ave., Bethpage, Long Island, N.Y. 11714
Gulf & Western Industries, 1 Gulf & Western Plaza, New York, N.Y. 10023
G&W Electric Specialty Co., 3544 West 127th St., Blue Island, Ill. 60406
Honeywell, Honeywell Plaza at 27th St., Minneapolis, Minn. 55408
Horizons, 23800 Mercantile Rd., Cleveland, Ohio 44122 (affiliated with Horizons Research)
Houston Natural Gas Corp., P.O. Box 1188, Houston, Tex 77001
Indian Head, 1211 Ave. of the Americas, New York, N.Y. 10036
Instrumentation Laboratory, 113 Hartwell Ave., Lexington, Mass. 02173
International Business Machines Corp., Old Orchard Rd., Armonk, N.Y. 10504
International Harvester Co., 401 North Michigan Ave., Chicago, Ill. 60611
International Playtex, 888 Seventh Ave., New York, N.Y. 10019 (division of Esmark)
Interpace Corp., 260 Cherry Hill Rd., Parsippany, N.J. 07054
Ionics, 65 Grove St., Watertown, Mass. 02172
Itek Corp., 10 Maguire Rd., Lexington, Mass. 02173
Johns-Manville Corp., P.O. Box 5108, Denver, Colo. 80217
S. C. Johnson & Son, 1525 Howe St., Racine, Wis. 53403
Johnson & Johnson, 501 George St., New Brunswick, N.J. 08903
Jones-Blair Co., P.O. Box 35286, Dallas, Tex. 75235
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Liggett Group, 4100 Roxboro Rd., Durham, N.C. 27702
Litton Industries, 360 North Crescent Dr., Beverly Hills, Calif. 90210
Lockheed Aircraft Corp., 2555 North Hollywood Way, Burbank, Calif. 91503
Loctite Corp., 999 North Mountain Rd., Newington, Conn. 06111
P. Lorillard Co., 200 East 42nd St., New York, N.Y. 10017 (subsidiary of Loews Corp.)
LTV Corp., 1525 Elm St., Dallas, Tex. 75201
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P. R. Mallory & Co., 3029 East Washington St., Indianapolis, Ind. 46206
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Masonite Corp., 29 North Wacker Dr., Chicago, Ill. 60606
McDonnell Douglas Corp., P.O. Box 516, St. Louis, Mo. 63166
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Mine Safety Appliances Co., 608 Penn Center Blvd., Pittsburgh, Pa. 15235
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Nashua Corp., 44 Franklin St., Nashua, N.H. 03060
National Can Corp., 5959 South Cicero Ave., Chicago, Ill. 60638
National Gypsum Co., 4100 First International Bldg., Dallas, Tex. 75270
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NL Industries, 111 Broadway, New York, N.Y. 10006
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Norton Co., 50 New Bond St., Worcester, Mass. 01606
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Ralph M. Parsons Co., 100 West Walnut St., Pasedena, Calif. 91124
PCR, P.O. Box 1466, Gainesville, Fla. 32601
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Research-Cottrell, P.O. Box 1500, Somerville, N.J. 08876
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Carnegie-Mellon Institute of Research, 4400 Fifth Ave., Pittsburgh, Pa. 15213
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Gillette Research Institute, 1413 Research Blvd., Rockville, Md. 20850
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Institute of Gas Technology, 3424 South State St., Chicago, Ill. 60616
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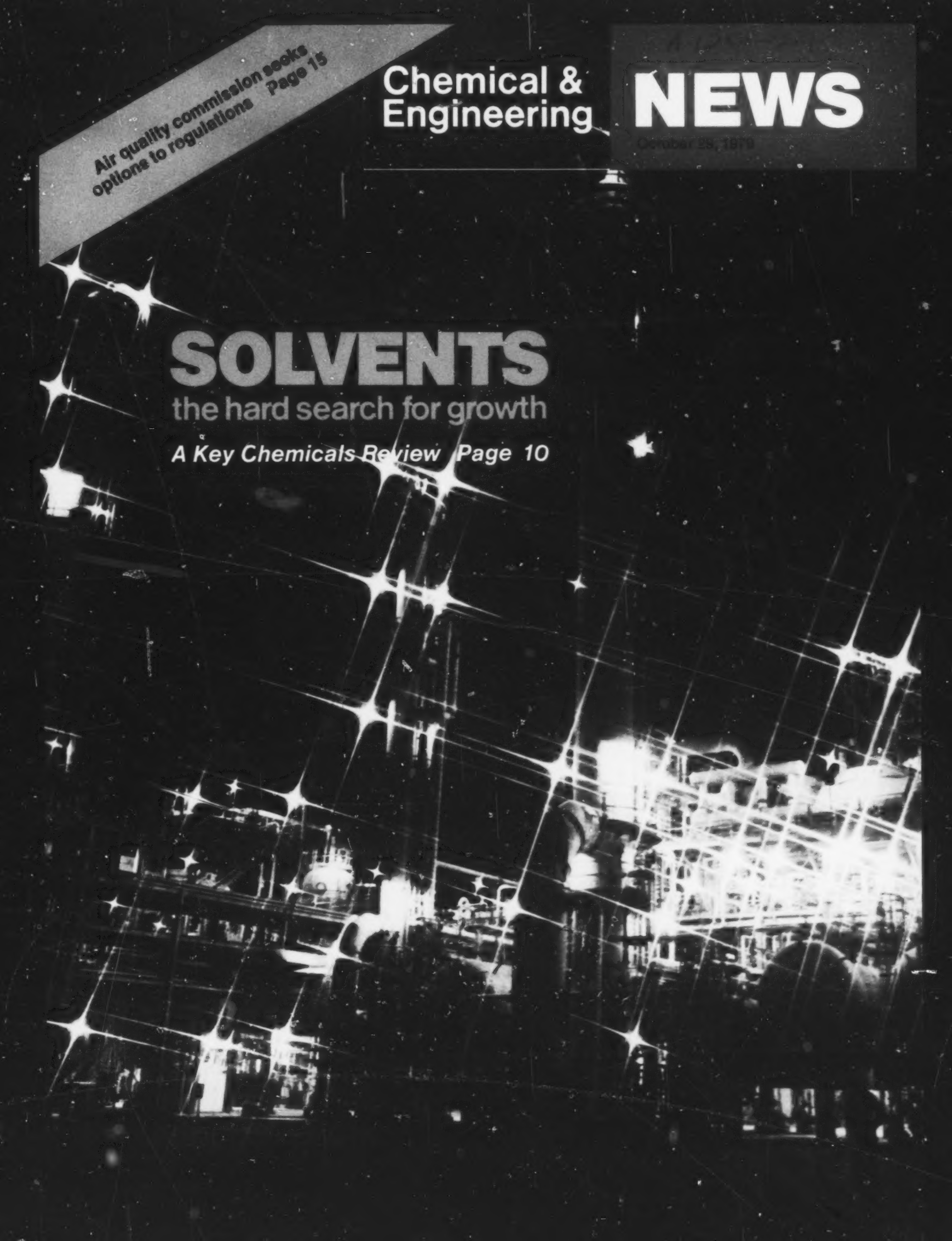
SRI International, 333 Ravenswood Ave., Menlo Park, Calif. 94025
Sterling-Winthrop Research Institute, Columbia Tpke., Rensselaer, N.Y. 12144 (division of Sterling Drug)
Underwriters Laboratories, 207 East Ohio St., Chicago, Ill. 60611
United States Testing Co., 1941 Park Ave., Hoboken, N.J. 07030

Chemical & Engineering NEWS

October 29, 1979

Air quality commission seeks options to regulations Page 15



SOLVENTS

the hard search for growth

A Key Chemicals Review Page 10

October 29, 1979
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Chemical & Engineering NEWS

Cover: PPG Industries' 1,1,1-trichloroethane solvent plant at Lake Charles, La., which came on stream early this year

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News of the Week

- ***Third-quarter chemical earnings*** *of major oil companies have risen even faster than their earnings from all operations.* **Page 6**
- ***No apparent excess deaths from dioxin*** *exposure is conclusion of mortality study of Monsanto workers accidentally exposed to chemical 30 years ago.* **Page 7**
- ***An experimental electroplating method*** *that uses a laser to enhance metal deposition over small areas has been developed by scientists at IBM.* **Page 7**
- ***Analytical instrument show,*** *Expochem 79, was held in Houston last week—the first time in the Sunbelt for a major analytical conference.* **Page 7**
- ***Hybrid polyethylene*** *called linear low-density polyethylene made via low-pressure process has been disclosed by Dow.* **Page 8**
- ***Toxic chemical contamination cases*** *involving two companies—Hooker Chemicals & Plastics and Velsicol Chemical—have been settled out of court.* **Page 8**

Business

- ***Ethanol and 1,1,1-trichloroethane,*** *key solvents, reflect 1979 downturn, with demand slow, production expansion and use growth stalled.* **Page 10**

Government

- ***Alternatives to present air quality rules*** *and five regions for testing them will be studied by special commission, which will suggest changes to Congress.* **Page 15**
- ***Symposium on innovation*** *discloses MIT's concept of government's role—it should stand aside so that only the fittest companies survive.* **Page 17**

Science

- ***Relations between academic and industrial chemists,*** *beset by differing priorities, comprised the agenda of a conference at Dow, which aired problems, especially money, considered solutions.* **Page 20**
- ***Antiprotons among cosmic rays*** *have been observed for the first time outside a laboratory, in an experiment aboard a balloon over the Southwest.* **Page 22**
- ***A new moon of Jupiter,*** *the fourteenth, has been detected in pictures taken July 8 by Voyager 2; moon could be fastest-moving satellite in solar system.* **Page 22**

Technology

- ***Sewage-treatment system*** *(Thetford's Cycle-Let) holds big promise: cuts freshwater use up to 90%, cleans wastewater enough for utility uses, eliminates need for septic tanks and sewers.* **Page 25**

ACS News

- ***Updated edition of the safety manual,*** *"Safety in Academic Chemistry Laboratories," is being offered by ACS.* **Page 27**
- ***Official reports*** *of committees of the ACS Board of Directors and Council from the Washington national meeting.* **Page 28**

PETROCHEMICAL PROFITS SOAR IN THIRD QUARTER

Although the huge increases in oil companies' third-quarter profits have been gaining headlines lately, little noticed is that chemical earnings among these companies have grown even more rapidly than their earnings from all operations.

For five oil companies that released their third-quarter reports last week—Exxon, Gulf, Standard Oil (Indiana), Mobil, and Conoco—combined earnings from their chemical operations totaled $299.5 million for the third quarter. This is an average increase of 126.9% from the $132 million that their chemical operations posted in the third quarter of 1978. At the same time, combined third-quarter earnings from all operations of the five companies totaled $2.9 billion, an increase of 88.6% over last year's third quarter.

The same situation holds true for the first nine months of this year. During that time, profits of the five oil companies combined increased 39.7% to $7.5 billion. However, earnings from chemical operations shot up 116.8% to $839.6 million for the first three quarters of 1979.

The improvement of the oil companies' chemical business has served to run up profits from chemicals as a per cent of total profits. For the third quarter of 1979, chemical profits made up 10.2% of total earnings for the five oil producers. In the third quarter of 1978, chemical profits were a more modest 8.5% of total oil company profits. The increase is even more dramatic for the first nine months of this year, when chemical earnings were 11.3% of the total. Chemical earnings in the same period of 1978 made up just 7.3% of the five oil companies' total earnings.

Chemical operations at the oil companies also are outperforming earnings at the traditional chemical companies. While chemical earnings at the oil companies were more than doubling, earnings among 15 top chemical companies were increasing about 25% in the third quarter on a sales increase of 26%. Thus, the average profit margin for these chemical firms was 5.9%, the same as it had been in the third quarter of 1978. For the first nine months of 1979, the 15 chemical companies increased earnings a little more than they did in the third quarter, with an average increase of 27.8% over the first nine months of 1978.

The 25% earnings increase among the 15 chemical companies, though

Chemical earnings at oil firms skyrocket 127% . . .

	THIRD QUARTER					FIRST NINE MONTHS				
	Chemical earnings		%	Chemical earnings as % of total earnings		Chemical earnings		%	Chemical earnings as % of total earnings	
$ Millions	1979	1978	change	1979	1978	1979	1978	change	1979	1978
Exxon	$103.0	$66.0	56.1%	7.1%	12.3%	$320	$189	69.0%	10.9%	10.0%
Gulf Oil	82	16	412	19.7	7.6	196	52	276	20.5	10.0
Standard Oil (Ind.)	57.8	11.1	421	13.3	3.8	150.6	49.4	205	12.7	5.7
Mobil Oil	36.0	23.0	56.5	6.1	8.9	95.0	55.0	72.7	6.6	6.9
Conoco	20.7	15.9	30.2	8.4	15.0	78.0	41.8	86.6	12.5	14.1
TOTAL	$299.5	$132.0	126.9%	10.2%	8.5%	$839.6	$387.2	116.8%	11.3%	7.3%

. . . far outshining big 25% earnings rise for chemical companies

	THIRD-QUARTER 1979						FIRST NINE MONTHS 1979					
		Change from		Change from	After-tax income as % of sales			Change from		Change from	After-tax income as % of sales	
$ Millions	Sales	1978	Earnings[a]	1978	1979	1978	Sales	1978	Earnings[a]	1978	1979	1978
Du Pont	$3,133.2	17.9%	$234.0	13.9%	7.5%	7.8%	$9,395.3	18.9%	$707.7	26.5%	7.5%	7.1%
Dow Chemical	2,426.4	44.9	198.4	29.3	8.2	9.2	6,808.1	34.3	589.6	35.0	8.7	8.6
Union Carbide	2,325.7	14.5	138.6	71.7	6.0	4.1	6,780.2	17.3	413.7	55.3	6.1	4.6
Monsanto	1,496.7	26.1	82.1	75.4	5.5	3.9	4,647.3	25.1	303.4	17.3	6.5	7.0
W. R. Grace	1,278.6	22.4	57.3	42.5	4.5	3.8	3,781.1	17.5	153.3	17.4	4.1	4.1
Allied Chemical	1,250.6	70	19.2	−42.9	1.5	4.6	3,034.1	35.6	108.2	−4.7	3.6	5.1
American Cyanamid	782.0	14.8	35.7	−1.0	4.6	5.3	2,330.0	14.2	119.6	6.8	5.1	5.5
Celanese	778.0	20	37.0	12	4.8	5.1	2,332.0	21	114.0	48	4.9	4.0
Diamond Shamrock[b]	606.0	32.3	37.1	25	5.3	6.5	1,700	30.8	119.6	29	7.0	7.2
Hercules	605.0	23	41.4	28.2	6.8	6.6	1,749.0	22	117.7	49.9	6.7	5.5
National Distillers	491.0	10.8	26.2	6.9	5.3	5.5	1,600	23.1	88.8	16.7	5.6	5.7
Ethyl Corp.	442.0	23	28.0	21.0	6.3	6.5	1,225.9	78.0	75.5	14.9	6.2	6.3
Olin	428.1	10.0	10.8	−41.0	2.5	4.7	1,337.1	16.1	55.6	15.6	4.2	4.2
Rohm & Haas	391.9	30.2	26.2	88.5	6.7	4.6	1,202.7	27.3	72.5	82.7	6.4	4.7
Stauffer Chemical	312.5	15.7	11.0	−33.3	5.0	6.1	1,156.4	15.2	95.9	4.0	8.3	9.2
TOTAL	$16,747.7	26.0%	$983.0	24.8%	5.9%	5.9%	$49,079.2	21.8%	$3135.1	27.8%	6.4%	6.1%

[a] After-tax, before extraordinary or nonrecurring items. [b] Includes extraordinaires.

large, may be the first indication that earnings gains for the chemical companies reached their peak in the second quarter. At that time, earnings for the top 20 chemical companies, from which this sample of 15 companies is gathered, climbed 33% over the previous year's second quarter (C&EN, Aug. 13, page 8). □

Study shows few health effects from dioxin

A mortality study of the 121 Monsanto workers believed to have been exposed to tetrachlorodibenzo-*p*-dioxin (TCDD) in an industrial accident 30 years ago has found surprisingly few long-term health effects.

The study finds no apparent excess of deaths in these workers from either cancer or cardiovascular disease. And the 32 total number of deaths so far among the workers is less than would be expected from the national average.

The study, which has been accepted for publication later this year in the *Journal of Occupational Medicine*, was conducted by Monsanto epidemiologist Judith A. Zack and by Raymond R. Suskind, director of the Institute of Environmental Health at the University of Cincinnati Medical Center.

Monsanto says the study covers all 121 of the workers from the company's Nitro, W.Va., 2,4,5-T plant who developed a skin condition called chloracne after an explosion at the plant in 1949. Chloracne is a skin eruption that is closely associated with exposure to certain chlorinated organic compounds, including TCDD. Some toxicologists, such as Richard J. Kociba of Dow Chemical, argue that it is the most sensitive short-term indication of dioxin exposure in humans.

The accident at Nitro was the earliest recorded incident of dioxin exposure involving a population of this size. Thus, this comprehensive followup, the authors say, represents the best opportunity so far to study the long-term effects of dioxin on mortality. All 121 people were traced through plant medical records, workmen's compensation files, and, where applicable, official death certificates.

The Monsanto study adds weight to the supposition of some toxicologists that TCDD, although extremely toxic to several types of animals, may be much less so to humans. This view has been based primarily on data available from an industrial accident that released TCDD over a portion of the town of Seveso, Italy, in 1976. There, about 700 people were temporarily evacuated from their homes as a result of the accident, and eventually more than 100 cases of chloracne were reported, mostly among children. So far, however, no human deaths have been directly attributed to TCDD exposure.

The Monsanto mortality study is only the first part of a larger analysis, based on mortality data as well as health information gathered last June in examinations of more than 400 present and former Nitro plant employees, Monsanto says. This study will include both workers exposed in the 1949 accident and workers, not exposed at that time, who worked in the 2,4,5-T operation between startup in 1948 and 1969 when Monsanto stopped making 2,4,5-T. These workers will be compared with a control group of employees from other areas of the plant. □

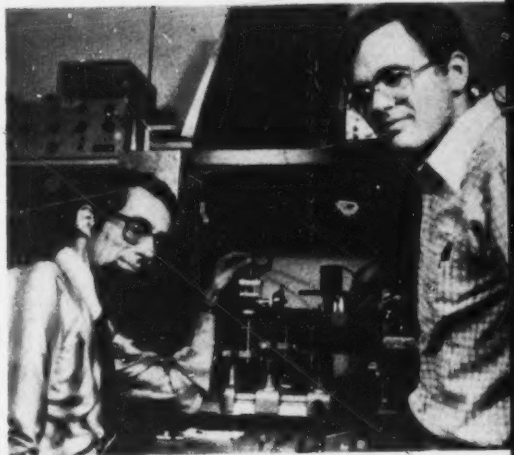
IBM develops laser electroplating method

Research scientists at International Business Machines' Yorktown Heights, N.Y., facility have developed an experimental electroplating technique that uses a laser to enhance metal deposition over small areas. The technique could lead to a simpler way of producing the small metal patterns in electronic circuitry, doing away with need for the overlaid "masks" that are used in fabricating conventional photolithographic circuits.

With the new technique, a finely focused laser beam heats up a small surface area on which metallic material is to be deposited and enhances deposition of the metal, IBM's Robert J. von Gutfeld told the semiannual meeting of the Electrochemical Society in Los Angeles. The technique was developed by von Gutfeld and Robert L. Melcher, with additional contributions from Lubomyr Romankiw, Samuel E. Blum, and Eugene E. Tynan.

Cathodes used in IBM's experiments were of tungsten, molybdenum, or nickel, in layers about 0.1 micrometer thick, predeposited on glass substrates. Anodes can be of platinum and chemically inactive in the plating process, or of the metal being deposited, the IBM scientists point out.

The lasers employed were continuous-wave argon (1.5 watt output power) or krypton (about 0.1 watt), with a mechanical light chopper to supply millisecond optical pulses when desired. A plating voltage of about 1.5 volts was used with plating solutions of dissolved salts of gold, nickel, or copper.



IBM's von Gutfeld and Melcher with their experimental electroplating system

As one example of the technique's use, 600 to 1000 times as much nickel was deposited on areas of tungsten irradiated by the laser as was deposited on the nonirradiated regions. Incident optical power was about 5000 watts per sq cm.

Using the technique, the IBM researchers have been able to electroplate areas as small as 4 micrometers in diameter.

The IBM scientists have evolved a conceptual model for the laser-enhanced plating effect. It arises, they believe, from sharply defined thermal gradients produced by the laser beam. The absolute change in temperature is only about 50° C for an incident beam of 500 milliwatts and 300 micrometers in diameter, they explain. But the change occurs over such a small distance that it produces intense convective effects. According to the model, the laser-induced convection causes the layer of solution next to the cathode to move from the cathode, thus promoting the inflow of new, ion-rich solution. □

Sunbelt gets new analytical meeting

Analytical instrument conferences and exhibits have tended to concentrate in the Northeast and Midwest. Now the Sunbelt is getting one, too.

Expochem 79, with the date to be changed to fit the year, kicked off last week in Houston with a four-day program. According to Albert Zlatkis, chairman of the organizing committee for the international exposition, it will become an annual meeting to serve the large academic, industrial, and biomedical analysis community of the Gulf Coast region.

Outlook for organic solvents remains bleak

Growth in demand continues to be slack because of high costs of raw materials and environmental problems in solvent use and disposal

Organic solvents of all kinds—and the U.S. solvents industry as a whole—are getting an ever-more-tarnished business image as the 1970's draw to a close. The heady days of high growth rates for investment and production appear to be over, despite some vigorous attempts at renewal in recent years.

For a variety of reasons, production growth in the next few years for these materials will be low, mostly from 0 to 3% per year, with some declines possible. The spreading U.S. recession won't help, nor the relentless increase in cost of raw material hydrocarbons.

But, more fundamentally, organic solvents will continue to suffer from a boomerang effect of their most useful property, dissolving power. Powerful solvents can conveniently carry a host of other organics such as paint to desired uses. Other solvents can just as conveniently carry unwanted oil, dirt, and other substances away from use areas.

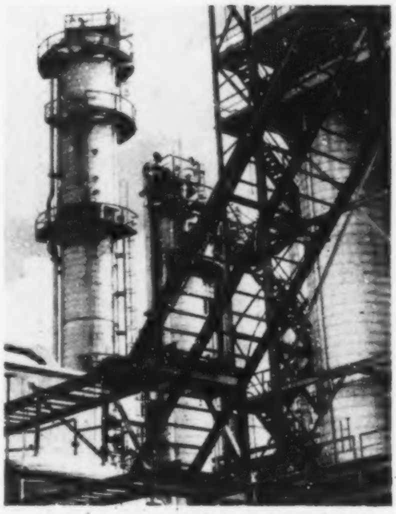
But then the trouble starts. Since solvents are carriers, they must eventually be disposed of once their usefulness is ended. If disposal cannot be strictly controlled, the solvents are vented to the workplace or the atmosphere. There, they become pollutants and possibly worse.

For more than a decade, a governmental crackdown on solvent emissions and inconclusive testing on the toxicity of these emissions has curbed organic solvent use. At the same time, development of competing solvent materials, notably plain water, or of solventless product delivery has hurt future growth for the organics.

In the end, some compounds known traditionally as solvents may grow more in the future in nonsolvent uses. That's already true for acetone, a strong solvent whose main use now is as a raw material for methyl methacrylate. Ethanol's chief growth chance now is as a fuel in combination with gasoline. Methylene chloride has pinned much hope on growth as a propellent in aerosols.

For the 1970's, organic solvents came out in something of a draw. Gains in some compensated for steep declines in others. For the six leading oxygenated and chlorinated hydrocarbons used mainly as solvents, U.S. merchant sales volume this year will be just about what it was in 1969 at 3.4 billion lb. These compounds are ethanol, methyl ethyl ketone, perchloroethylene, methylene chloride, 1,1,1-trichloroethane, and trichloroethylene.

Because of hugely inflated raw material hydrocarbon costs, merchant market value for these solvents will be much more than 10 years ago, about $785 million in 1979 compared to the $254 million in 1969 measured by the International Trade Commission. Average value per pound will have almost tripled in 1979, to 23 cents from 8 cents in 1969.



Union Carbide's Texas City, Tex., ethanol plant is one of world's largest

The big increase in market value for these solvents is some compensation for producers amid the ups and downs in specific products. Solvents are an overwhelmingly merchant business, with less than 15% of production for the six major oxygenated and chlorinated compounds used captively. That's been true for the past decade.

Since solvents have such high merchant exposure, market growth is especially important. Big investment has been committed in the past few years to increase markets.

The latest, and possibly saddest

Major U.S. solvents had low average annual production growth rates over past decade

Millions of lb unless otherwise noted	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	% average annual growth, 1969–79
CHLORINATED												
Perchloroethylene	670	722	664	669	679	734	706	734	705	707	635	0.5%
Methylene chloride	625	567	478	538	497	608	520	471	401	402	366	5.5
1,1,1-Trichloroethane	600	623	635	631	459	592	546	441	375	366	324	6.4
Trichloroethylene	240	301	298	316	293	385	452	427	515	611	597	−8.7
OXYGENATED												
Acetone (billions of lb)	2.48	2.11	2.22	1.92	1.64	1.98	1.99	1.74	1.54	1.62	1.52	5.0
Ethanol (millions of gal)	196	190	194	224	209	239	299	264	239	299	358	−5.8
Methyl ethyl ketone	569	598	512	524	425	506	541	509	484	480	484	1.6

Sources: International Trade Commission, industry estimates case, is 1,1,1-trichloroethane—whose immediate market prospects, together with ethanol's, is given on the following pages. Hopes ran high for 1,1,1-trichloroethane five years ago as the compound seemed to capture markets lost by trichloroethylene and perchloroethylene. By 1976, 1,1,1-trichloroethane nearly doubled in production from 1969 to 631 million lb.

Then all three 1,1,1-trichloroethane producers—Dow Chemical, PPG Industries, and Vulcan Materials—sank money into new production units. These expansions came on stream in 1978 and 1979, nearly doubling industry capacity to 1.29 billion lb by first-quarter 1980.

Unfortunately, 1,1,1-trichloroethane's market went flat just as these plants were being constructed. Production this year will be less than in 1976, even with a boost from exports. Market growth, by capture or any other means, simply didn't materialize. This leaves producers with the unhappy prospect of plant use running 50% for the next year.

For other solvents, the 1970's haven't brought such shocking market turns. But the results haven't been encouraging either. Both perchloroethylene and trichloroethylene, the two traditional top chlorinated solvents, will finish the 1970's with less production then at the start of the decade. Both have been hurt by solvent emission controls, especially for trichloroethylene, whose market has dropped by more than half.

In oxygenated solvents, ethanol has suffered the same volume fate as trichloroethylene, but for a different reason. Ethanol lost a billion pound, largely captive market when acetaldehyde producers switched starting material from ethanol to ethylene. Ethanol's merchant shipments fell only 8% from 1969 through 1979, because solvent uses nearly held up. Solvent use of ethanol will continue to show no growth or a slight decline in coming years, producers expect.

For the present, chlorinated solvents are in a year of no overall growth. In 1978, production of the three most important two-carbon chlorinated solvents totaled about 1.65 billion lb. This might not be exceeded in 1979, if estimates of production thus far are extrapolated to an annual basis. More likely, production in 1979 will be off a bit to around 1.5 billion lb for these three.

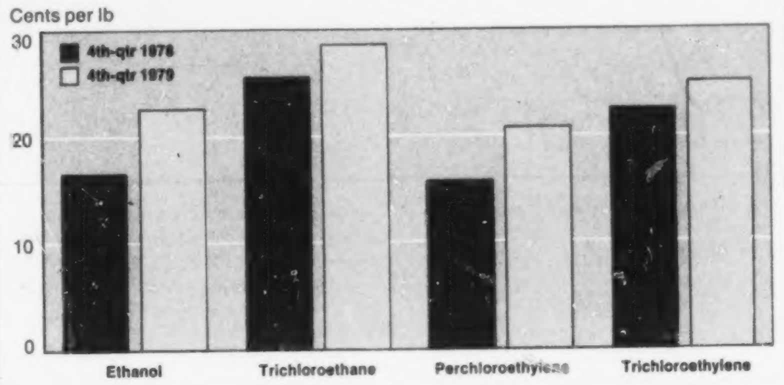
The other commercially important chlorinated solvents are derivatives of methane. Some of these—methyl chloride (made either from methane or methanol), methylene chloride, chloroform, and carbon tetrachloride—find many more diverse nonsolvent uses than do the C_2 chlorinated hydrocarbons.

Production of chlorinated methanes in 1978 totaled about 2.1 billion lb. Production in 1979 should about equal this based on production thus far.

In the oxygenated solvents, 1979 is turning up slightly for synthetic ethanol but is falling to date for methyl ethyl ketone.

Aromatic and aliphatic hydrocarbons used as solvents fluctuate with competing gasoline demand. These products run the gamut of single compounds of high purity to mixtures whose composition varies because physical properties such as boiling point are used as specifications. The solvent uses of these hydrocarbons are relatively small compared to total consumption, largely in fuel. Most of these products are in the gasoline boiling range among distillates in refineries.

Prices of major solvents are up strongly



Organic solvents—four main classes

The U.S. organic solvents business is hard to pin down in its entirety because of the large number of compounds that find some use for their dissolving properties, even though they are not usually thought of as solvents.

Although in practice the word "solvents" is narrowed to mean the well-known oxygenated and chlorinated chemicals such as ethanol and perchloroethylene, the overall solvents business encompasses two other classes. These are aliphatic and aromatic hydrocarbons without oxygen or chlorine.

The aliphatics are mostly light petroleum distillates from oil refineries such as the mineral spirits used to thin alkyd paints. The aromatics are standard benzene, toluene, and xylene, which find a small part of their use as solvents. These, too, are largely products of the oil industry.

For aliphatic and aromatic hydrocarbons to be used as solvents, consumers must pay enough to match these hydrocarbon's value in competing uses, usually in some kind of fuel, plus the cost of separating and purifying them. Until the most recent round of crude oil price increases, price changes of many of these solvents were usually small but frequent, reflecting market conditions for gasoline.

In contrast, prices for oxygenated solvents produced in chemical plants have not changed so often, but had bigger changes in prices when they came, reflecting the differences in marketing of chemicals and fuels.

In chlorinated and oxygenated solvents, exports are going to be an important plus this year, as they have been for most chemicals. In Commerce Department figures, exports for the first half of 1979 were almost as much as full-year 1978 totals for the leading compounds—72% of 1978 exports for perchloroethylene, 94% for methylene chloride, 75% for 1,1,1-trichloroethane, 91% for trichloroethylene, 64% for ethanol, and 94% for methyl ethyl ketone. Exports are particularly important to trichloroethylene and, if they continue as in the first half, will account for about one fourth of full-year 1979 U.S. production.

The robust state of solvent exports, ironically, puts even more caution into forecasts for 1980. Even with these exports, solvents are having a generally no-growth year in 1979 U.S. production. If other economies begin to grow more slowly in 1980 or 1981, or if the raw material cost advantage enjoyed by the U.S. begins to decline, exports may not pack as much punch a year from now.

William F. Fallwell and William J. Storck, C&EN New York; Bruce F. Greek, C&EN Houston

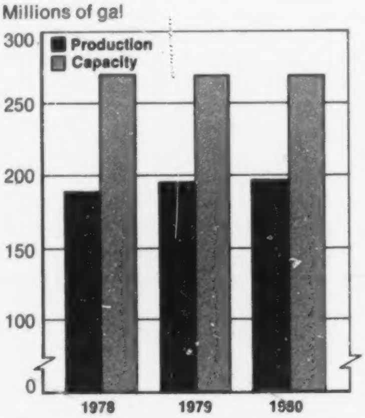
Key Chemicals

Ethanol

CH_3CH_2OH

- ***Demand slow***
- ***Capacity flat***
- ***Prices rising***

PRODUCTION/CAPACITY



HOW MADE

Direct hydration of ethylene

MAJOR END USES

Solvents 55%, chemical intermediates 35%, food processing 7%

FOREIGN TRADE

Exports—rising to 9 million gal in 1979; Imports—falling somewhat to about 19 million gal

PRICES

\$1.53 per gal for 190-proof ethanol; \$1.65 per gal for anhydrous

COMMERCIAL VALUE

\$266 million for total production, 1979

Ethanol, which is much in the news lately as a result of its use in gasohol, would seem to have a lot going for it and, in general, it does. But synthetic ethanol, that which is made by the hydration of ethylene, is still languishing.

The apparent contradiction is caused by the structure of government energy programs. For ethanol to qualify for excise tax breaks, it must be made from renewable resources. This means that only ethanol made by fermentation can qualify.

Thus, synthetic ethanol receives little help from gasoline conservation programs. The only bright spot, and it is small, is that some fermentation alcohol that previously had been sold to the industrial market has been shifted to gasohol production, leaving the entire industrial area to synthetic. Fermentation alcohol in the industrial market has never been more than a few percent of synthetic production.

Ethanol producers thus expect a small surge in demand this year to make up for the fermentation alcohol that has been shifted out of the industrial marketplace. They expect that production will increase to about 196 million gal this year, about 3 to 5% higher than 1978, with most bets on the 3% side.

Demand for ethanol, however, is going to have to pick up greatly through the remainder of the year if producers are to meet their targets. Production of synthetic ethanol through August was 127.7 million gal, down 5% from the first eight months of 1978, according to figures from the International Trade Commission. The August figures are the latest available.

However, even a 3% rise is not much considering that, through 1978, production of synthetic ethanol fell an average of 5% per year during the past decade. For the past five years, the decline has been precipitous—more than 8% per year.

Ethanol makers believe the situation next year will be anybody's guess. They say the slowdown in the U.S. economy is already being felt in ethanol demand. If production does increase in 1980, it will be no more than 1% above 1979. And some say that production will fall next year.

As a consequence of the lack of growth in ethanol demand, production capacity has been static for some time and will remain at 270 million gal for the foreseeable future, according to producers.

Ethanol's capacity use has fallen for several years, to about 70% in 1978. It may rise to about 73% for all of 1979, and will be at best about 74% for 1980.

One factor keeping capacity use down and depressing demand for domestic U.S. ethanol is imports. In 1978, imports of ethanol for industrial purposes totaled 22 million gal, mostly from the U.K., and, in fact, mostly from British Petroleum. Producers say that BP has made a conscious effort to gain part of the U.S. market. This 22 million gal of ethanol was equal to about 12% of domestic production.

This year imports may fall somewhat, but they are expected to be at least 19 million gal. This would be a little less than 10% of domestic production. Exports, by contrast, will be no more than 9 million gal in 1979.

In spite of ethanol's low capacity use and significant imports, producers have had little or no trouble maintaining price increases. However, these increases have been mostly cost passthroughs. The latest increase occurred on Oct. 1, when the price of 190-proof ethanol rose 8.5% to \$1.53 per gal. Anhydrous ethanol, which amounts to about 40% of U.S. production and is used as a chemical intermediate where the presence of water would be detrimental, is 12 cents a gal higher. The price spread between 190 proof and anhydrous ethanol has increased since the beginning of the year. At that time, there was only a 10 cent-per-gal difference between the two.

The present base price of \$1.53 per gal is 29% higher than \$1.185 on Jan. 1 of this year. The anhydrous price is 28% more than it was at the beginning of the year. Producers think that they will be able to continue to pass through increased production and distribution costs to their customers, but will get no further increase for profits.

Lacking a single area of good growth, ethanol will continue to have relatively low capacity use. With 25% and more of idle capacity haunting the industry, producers will be hard put to increase profit margins on their sales.

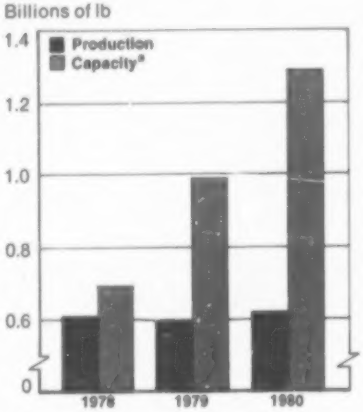
Key Chemicals

Cl_3CCH_3

1,1,1-Trichloroethane

- ***Demand growth slow***
- ***Capacity bulging***
- ***Prices catching up***

PRODUCTION/CAPACITY



a Nameplate capacity as of first quarter.

HOW MADE

Chlorination of ethane; hydrochlorination of vinyl chloride or vinylidene chloride made from ethylene dichloride

MAJOR END USES

Metal cleaning 70%, solvents for adhesives, coatings, inks, and the like 20%, aerosols 5%

FOREIGN TRADE

Exports—less than 10% of production; imports—negligible

PRICES

$3.15 per gal directly to consumers; price discounted to distributors

COMMERCIAL VALUE

$150 million for estimated production, 1979

The up-and-coming member of the chlorinated solvents' family has stumbled. Because of its favorable physical properties, 1,1,1-trichloroethane had production growth rates until last year in the 7 to 10%-per-year range, well above rates for most other chlorinated solvents. However, estimates of 1978 and 1979 production and forecasts for 1980 production of this solvent reduce growth rates to 3% or less. At the same time, much new production capacity has come on stream at the three U.S. producers—Dow Chemical, PPG Industries, and Vulcan Materials.

Specifically, production of 1,1,1-trichloroethane in 1979 will be lucky to top 600 million lb. A production forecast of 625 million lb, equal to 1978 production, from some market sources might be too optimistic. Forecast production of 625 million lb in 1980, taking into account effects of a U.S. recession, could also prove optimistic.

Yet, nameplate capacity grew by 300 million lb in 1978 and about the same in 1979, to bring operating capacity to about 1.3 billion lb as 1980 begins. This means U.S. producers will operate at only 50% of nameplate capacity during 1980 to meet even an optimistic demand level.

Two years ago, the picture for 1,1,1-trichloroethane capacity use was much better. As 1978 opened, capacity was under 700 million lb. Production that year was about 625 million lb. Assuming that the large new capacity in 1978 produced a third of its nameplate maximum during the year, producers had an average plant operating rate of over 75%.

In 1979, capacity use for 1,1,1-trichloroethane plummeted. If production only comes to 600 million lb, and if 200 million lb a year of the new nameplate capacity is used during 1979, the use rate falls to nearly 50% of nameplate. Some production problems have been experienced during 1979, so individual company rates could be higher.

The result, obviously, is that no more capacity expansions will occur for 1,1,1-trichloroethane for some time. Meanwhile, efforts are under way in producers' laboratories to expand present uses of the material and to find large-volume new uses. Success has eluded developers so far.

Most of the development work has been to reformulate adhesives and coatings which use solvents, with the aim of using 1,1,1-trichloroethane in place of hydrocarbon solvents. This chlorinated organic is considered nonflammable and apparently has little effect on the environment, in contrast to many other hydrocarbon solvents.

However, gains for 1,1,1-trichloroethane at the expense of other solvents, such as aromatics, so far have been small, at least in adhesives and coatings. Gains in other end uses were large for a while and led to growth forecasts which, because of environmental problems of the other major chlorinated C_2 compounds, notably perchloroethylene and trichloroethylene, proved to be overly optimistic.

In the early 1970's, 1,1,1-trichloroethane replaced some trichloroethylene as a metal-cleaning and degreasing material. Much of this resulted from governmental attacks on trichloroethylene as a contributor to smog and as a possible carcinogen. In locations where smog is a problem, requirements for vapor emission controls took effect more than 10 years ago. Because of the high cost of control systems, metal-cleaning operators turned to 1,1,1-trichloroethane, whose basic price is higher, as a less expensive way to meet control standards.

In locations where smog hasn't been a problem, the change from trichloroethylene has been slow. Minor switches to 1,1,1-trichloroethane sometimes occur as new information appears on studies of potential carcinogenesis. On the whole, 1,1,1-trichloroethane is still a long way from replacing trichloroethylene.

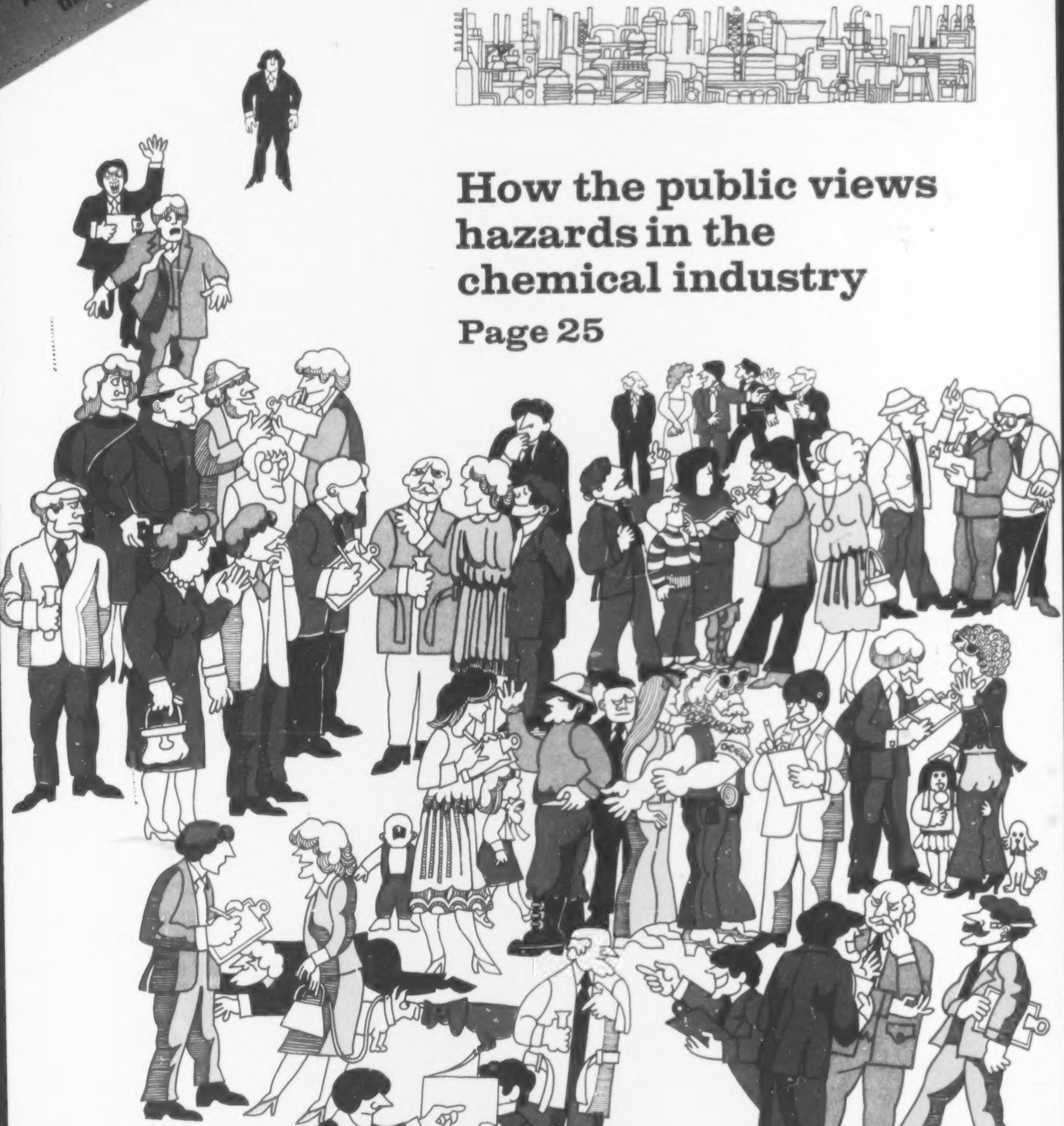
Cleaning with 1,1,1-trichloroethane tends more toward sophisticated uses in contrast with other chlorinated hydrocarbons. In recent years, this material has gotten the nod for such specialized areas as electrical equipment and aerospace components.

These uses, while robust, are not growing as they had in the past, nor are more conventional uses in the machined-products category. As a result, 1,1,1-trichloroethane will get little production expansion over the next year as long as U.S. manufacturing growth remains stalled.

Acquisitions have given W. R. Grace the balance it wants Page 10

Chemical & Engineering NEWS

November 5, 1979



How the public views hazards in the chemical industry

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West European outlook for olefins is mixed

Near-term prospects for both ethylene and propylene are good, but butadiene appears headed for huge surplus of some 1 billion lb by 1985

Ethylene use in Western Europe may grow almost 5% a year up to 1985. But even at that rate, ethylene plants on average will be operating at less than 8% of their nameplate capacity in 1985.

This forecast for ethylene, as well as for other low-molecular-weight olefins was presented by Ronald W. Russell, vice president for petrochemicals at Phillips Petroleum Chemicals' European headquarters in Brussels at the annual meeting of the European Chemical Marketing Research Association held recently in Munich. The meeting was held jointly with the U.S. Chemical Marketing Research Association.

According to Russell, the near-term prospects for propylene in Western Europe look brighter. Demand between 1978 and 1985 will grow 6% per year. In 1985, there is the likelihood of a propylene shortage approaching 300 million lb in contrast to a surplus of almost 300 million lb in 1978, and a surplus of nearly 1.7 billion lb in 1974.

The outlook for butadiene, on the other hand, appears decidedly bleak, he says. Even if consumption grows about 3% per year between 1978 and 1985 as expected, surplus of the chemical in Western Europe in 1985 will exceed 1 billion lb, compared to an excess of 913 million lb in 1978 and of 583 million lb in 1974.

The major share of Western Europe's ethylene goes to make low- and high-density polyethylene. In 1985, ethylene used for local consumption and net exports of these polymers are expected to reach a combined 17.6 billion lb, up from 13 billion lb in 1978, the most recent year for which data are available. Their combined share of total ethylene consumption will continue to be about 53%, Russell says.

Growth of HDPE use in Western Europe will outpace that of LDPE. Between 1978 and 1985, demand for HDPE is forecast to expand at an average yearly rate of 6.4% (from 3 billion lb to more than 4.5 billion lb). Over the same time, LDPE's growth is pegged at a more sober 4.5%-per-year rate (from 8 billion lb to 11 billion lb). Russell expects combined net exports of the two polymers to grow at barely 0.5% annually to 1.8 billion lb in 1985.

Polyvinyl chloride will continue as the second-largest single outlet for European ethylene. In 1985, some 5.5 billion lb of the olefin will be required to make PVC, almost 17% of total ethylene use. Both West European demand and net exports of PVC are expected to grow about 4.5% per year.

Exports of ethylene derivatives from Western Europe far outweigh imports. The ethylene equivalent of exports in 1978 was more than 2.8 billion lb. Of this total, 42% went to countries in the Middle East and Africa, 20% to the Far East, 17% to Central and South America, 16% to Eastern Europe, and 5% to North America.

Imports totaled 460 million lb of ethylene equivalent. Products came from three areas—North America (62% of imports), Eastern Europe (29%), and Japan (9%).

The nearly 2.4 billion lb of net ethylene-equivalent exports last year amounted to just under 10% of Western Europe's consumption. That was down from 13% in 1974. The slide is expected to continue to about 7% in 1985 even though net exports, in volume terms, probably will remain es-

By 1985, West European ethylene consumption may surpass 30 billion lb. . .

Ethylene, millions of lb	1974	1978	1985	% annual growth 1974-78	% annual growth 1978-85
Demand for derivatives	19,745	21,901	30,360	2.6%	4.8%
Net exports of derivatives	2,915	2,376	2,387	−5.0	0.1
Total demand	22,660	24,277	32,747	1.7	4.4
Production	22,660	24,277	32,747	1.7	4.4
Nameplate capacity	27,984	32,329	42,680	3.7	4.1
Utilization rate of ethylene crackers (%)	81%	75%	77%		

. . . propylene may be in short supply. . .

Propylene, millions of lb	1974	1978	1985	% annual growth 1974-78	% annual growth 1978-85
Demand for derivatives	9,482	11,308	17,105	4.5%	6.1%
Net exports of derivatives	1,292	1,727	968	7.4	−8.0
Total demand	10,780	13,035	18,073	4.9	4.8
Production	12,452	13,332	17,776	1.7	4.2
Surplus	1,672	297	(297)		

. . . and butadiene surplus may exceed 1.1 billion lb

Butadiene, millions of lb	1974	1978	1985	% annual growth 1974-78	% annual growth 1978-85
Demand for derivatives	2,431	2,332	2,849	−1.0%	2.9%
Net exports of derivatives	198	242	242	5.1	0.0
Total demand	2,629	2,574	3,091	−0.5	2.6
Production	3,212	3,487	4,213	2.1	2.7
Surplus	583	913	1,122		

Source: Phillips Petroleum Chemicals

Low- and high-density polyethylene takes about half of West European ethylene

Millions of lb	1974			1978			1985[a]		
	West Europe demand	Net exports	Total ethylene demand	West Europe demand	Net exports	Total ethylene demand	West Europe demand	Net exports	Total ethylene demand
Low-density polyethylene	7,348	1397	8,745	8,272	1067	9,339	11,231	1100	12,331
High-density polyethylene	2,574	572	3,146	2,992	638	3,630	4,609	660	5,269
Polyvinyl chloride	3,333	407	3,740	3,850	187	4,037	5,236	253	5,489
Styrene thermoplastics	1,100	132	1,232	1,265	187	1,452	1,771	187	1,958
Ethylene glycol and other ethylene oxide derivatives	2,596	473	3,069	2,695	275	2,970	3,432	165	3,597
Other products	2,794	(66)	2,728	2,827	22	2,849	4,081	22	4,103
TOTAL	19,745	2915	22,660	21,901	2376	24,277	30,360	2387	32,747

a Estimates. **Source:** Phillips Petroleum Chemicals

sentially unchanged at about 2.2 billion lb of ethylene equivalent per year through the first half of the 1980's.

Russell doesn't look for any significant rise in the level of imports of ethylene derivatives in the immediate future. Noting that "U.S. producers have enjoyed significant advantages in ethylene costs," he argues that "U.S. exports may be expected to fall as these cost advantages become progressively eroded." Even the much-touted capacity buildup in Eastern Europe is, he notes, primarily being built to satisfy consumer demand there. Should 1985 imports from Eastern Europe rise to 550 million lb annually of ethylene equivalent from 1978's 132 million lb, which, he admits, is likely, the quantity would be less than 2% of the West European anticipated demand that year.

For the longer range, Russell has drawn up two possible scenarios for Western Europe's ethylene business in 1990.

The most optimistic view is that consumption of ethylene derivatives between 1985 and 1990 will grow 4% annually to reach 37 billion lb. Even if net exports, in terms of ethylene equivalent, were to fall to about 1 billion lb from the 2.4 billion lb level anticipated for 1985, this still would put ethylene demand at about 38 billion lb. Barring installation of capacity beyond that expected to be on stream in 1985, units could be operating at about 90% of nameplate capacity levels.

A gloomier view emerges from an alternate set of premises. One is that the rate of consumption of ethylene derivatives will grow at a less buoyant rate of 3% per year to 35.2 billion lb of ethylene equivalent. Another is that Western Europe will become a net importer of ethylene-derived products, perhaps by as much as 2.2 billion lb of ethylene equivalent. In addition, a further 2.2 billion lb of ethylene might be expected to reach Western Europe from producers in the Middle East.

If these factors were to materialize, Russell says, ethylene production in Western Europe would be about 31 billion lb. That level would represent a mere 72% of 1985 capacity.

A big question mark, of course, is the impact of the new ethylene units planned for the Middle East, North Africa, and Turkey. Annual capacity for that region will be about 8.8 billion lb, Russell says.

He estimates that in 1990 demand for ethylene derivatives in the region could consume up to 3.7 billion lb, assuming that per capita consumption matched the level reached in Western Europe around 1967. If the new plants were running at 80% of design capacity, there would be a surplus of some 3.3 billion lb. "This represents over 70% of the combined U.S. and West European exports [of ethylene equivalent derivatives] in 1978," he remarks.

The obvious question is where will the surplus go. Russell believes that countries in Africa and Asia would be the most likely targets for product sales. "Although in Africa south of the Sahara consumption will be modest, the aggregate tonnage of commodity plastics should absorb a reasonable proportion of the surplus," Russell says.

Such sales would encroach directly on established outlets of West European suppliers. And inevitably, some products will find their way into Western Europe. Indeed, Russell foresees the likelihood of some 2 billion lb of ethylene itself being shipped from the new plants to Europe.

Turning to propylene, "demand can be expected to grow in the 1980's at a higher rate than ethylene, probably 1 to 1.5% greater," Russell says. "Toward the end of the 1980's, feedstock supplies to steam crackers could be adjusted if the economics are favorable to allow production of greater quantities of propylene."

From the present propylene surplus position of about 33 million lb, Western Europe likely will move to a deficit of 300 million lb in 1985. By 1990, depending on cracker operations, availability could range from a surplus of 650 million lb to a deficit of 1.4 billion lb.

Western Europe's overall propylene needs exceeded 13 billion lb last year. Requirements for chemicals sold locally amounted to 11.3 billion lb. Well over one third of the quantity went to make polypropylene and acrylonitrile derivatives. Although exports of propylene-based products are expected to decline during the coming decade, demand in Western Europe is expected to grow at an annual rate of 6% to 1985, and 4% annually during the five years after that, according to Russell.

"Butadiene does not show such a rosy picture," Russell notes. "This is mainly due to the poor growth rates of styrene-butadiene rubbers." SBR consumption in Western Europe in 1978 involved use of 1.36 billion lb of butadiene, some 176 million lb less than the quantity in 1974. According to Russell's projection, the 1974 level won't be regained until 1990.

Europe's butadiene needs will grow modestly from the 1978 total of 2.33 billion lb to 2.85 billion lb in 1985, and to 3.14 billion lb in 1990. But the amount going to make synthetic rubbers will take a declining part of the total. Last year, this stood at 85% (2 billion lb). In 1985, Russell believes, the level will be closer to 82% (2.32 billion lb). By 1990, it will slip to about 81% (2.53 billion lb).

Moreover, Europe's exports of butadiene will be hit by the growing trend of U.S. ethylene producers to supplement their natural gas crackers with ones based on petroleum feedstocks that yield coproduct butadiene. Last year, Russell points out, about 880 million lb of the chemical was shipped from Europe, the bulk of it to the U.S. □

Hazards in the chemical industry

The public seems to view the industry as a greater threat to health and safety than do the workers it employs

Rene D. Zentner, Shell Oil

Even a cursory inspection of the press might suggest that the U.S. is in the grip of a rampant cancer epidemic. Reported causes are not hard to find: poisons in the air and water, poisons in food, poisons in the workplace. An examination of the number of accounts of cancer in the news media reveals that they have increased dramatically in the past decade.

Underlying data about the risk of cancer, however, indicate a somewhat different trend. According to the National Cancer Institute, the annual incidence of cancer has in fact been increasing since 1970, but at a rate of only 1 to 2% a year. Overall, trends in national air and water quality also are beginning to improve. Not all chemicals encountered in U.S. daily life, moreover, are likely to cause cancer. The 1977 annual report of the Council on Environmental Quality points out:

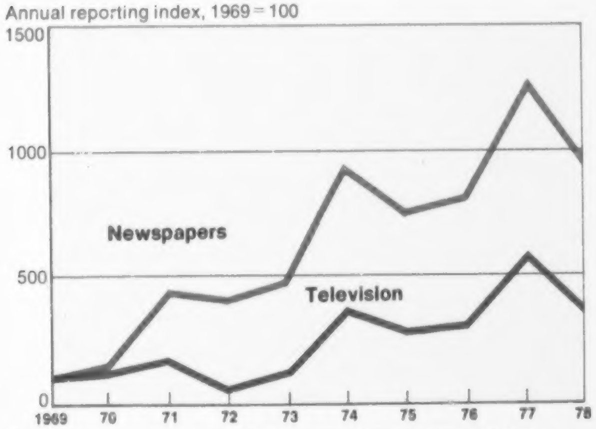
"It is important to note that carcinogenic chemicals are probably a small minority among the 3.5 million known chemicals. About 600 have been tested for carcinogenicity. Many were drugs and pesticides, which by definition are biologically active; less than 10% of the compounds have been found to be carcinogenic. In a random list of chemicals, a still lower percentage may be expected to exhibit carcinogenic activity. Of some 70,000 chemicals in commercial production, the *number* of carcinogens—in particular, the number to which there is widespread population exposure—may be quite small."

Cancer, nevertheless, has been the second greatest cause of death, after heart disease, for the past 40 years in the U.S. But this distinction is a relatively recent one. At the beginning of the 20th century, the three principal disease-based causes of death were heart disease, influenza/pneumonia, and tuberculosis; cancer ran a distant fifth. Since then, the incidence of influenza and pneumonia has been reduced by a factor of almost eight and that of tuberculosis by a factor of more than 100. Thanks to new drugs, they are no longer major killers. No miraculous drug, however, has emerged to conquer heart disease or cancer, whose incidence has risen since 1900.

Even so, there appears to be a discrepancy between increasing public apprehension about cancer, as indicated by news coverage devoted to the disease, and the actual change in risk associated with it.

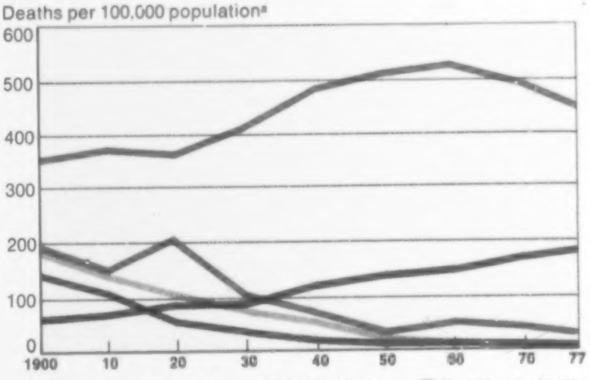
In the light of these developments, how indeed does the

News coverage of cancer is up sharply from decade ago



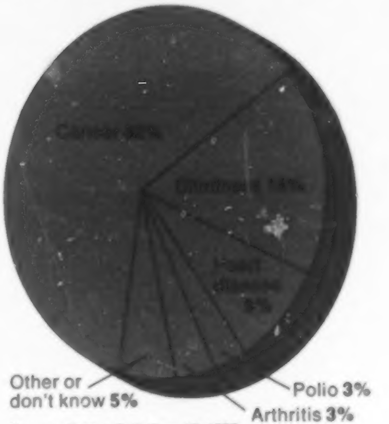
Sources: Television Archive, Vanderbilt University; New York Times Data Bank

Cancer has moved from fifth to second place among deadly diseases



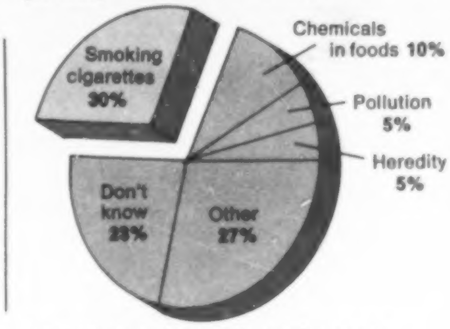
[a] Excludes fetal deaths. **Sources:** National Office of Vital Statistics, National Center for Health Statistics

Cancer is most-feared disease



Source: Gallup Poll, Dec. 10, 1965

Public views smoking as principal cause of cancer...



What do you think is the major cause of cancer today?

Source: Cambridge Reports Inc., "An Analysis of Public and Worker Attitudes Toward Carcinogens and Cancer Risk"

...and cancer scientists tend to agree

Causative factor[a]	% of U.S. cancer deaths
Environmental	
Cigarette smoking	30-35%
Imprudent diet	30-35
Occupation	1-2
Background radiation	2-4
Nonenvironmental	
Genetic	4-5
Unaccounted for	19-33

[a] Excludes superficial skin cancer. **Note:** Data are averages for estimates by various scientists at the National Cancer Institute, American Cancer Society, and elsewhere. **Source:** Elizabeth Whelan, "Preventing Cancer," W. W. Norton, New York, 1977

public view cancer and its causes and risks? What is the attitude of the public in general and of workers in the chemical industry regarding the role of chemicals and chemical plants in increasing cancer risks? And what is their opinion with respect to policy issues dealing with exposure to potential carcinogens?

Data pertinent to these questions are available from two types of sources. Syndicated studies like the Gallup Poll and Yankelovich, Skelly, and White's "Corporate Priorities" report are one. Two recent proprietary studies are another. In June 1977, Cambridge Reports surveyed public attitudes toward cancer risks for Union Carbide by means of 1500 personal interviews with a representative sample of adult Americans. The following year, Cambridge Reports made another study for Shell Oil, using a similar public sample but interviewing a sample of 200 chemical plant workers as well.

The Gallup Poll three times since 1947 has asked Americans which disease they dread the most. Each time the question has been posed, cancer has headed the list by a wide margin, although heart disease is responsible for several times as many deaths.

Americans are somewhat more likely to expect to contract some form of cancer than any other disease, including heart disease; this expectation is slightly greater among chemical workers than among the general public.

Cigarette smoking and environmental carcinogens currently are regarded as principal causes of cancer. For at least two decades, a majority of Americans have viewed cigarette smoking as a leading cause of lung cancer by a wide margin. And the margin is increasing. Between 1977 and 1978, the proportion of Americans who regard cigarettes as a major cause of cancer has increased by 12 percentage points to 30%; during the same period the proportion who cannot specify any major cause decreased by 11 percentage points to 23%.

That this perception has a basis in scientific evidence is supported by Dr. Elizabeth Whelan of the Harvard School of Public Health. In her recent book, "Preventing Cancer," she has collected opinions on causes of cancer from a group of scientists working on that disease. These scientists attribute about a third of all cancer deaths to cigarette smoking.

Despite their strong views on cigarettes and other causes of cancer, only about a quarter of Americans believe themselves well informed about cancer and its causes. The 1978 Cambridge Reports study shows that the majority of the public—and a somewhat larger proportion of chemical workers—consider themselves only somewhat informed. Few respondents claim, however, not to know how informed they are about cancer and its causes.

In the past few years, the public has increasingly perceived the chemical industry as a contributor to environmental pollution. Such episodes as the disposal of polychlorinated biphenyls in the Hudson River and of the polychlorinated hydrocarbon pesticide Kepone in the James River have increased public concern about the effects of chemical products on air and water. The revelation of the long-term effects of chemicals buried in the Love Canal area of Niagara Falls, N.Y., has created anxiety in residents of areas where the chemical industry is highly concentrated. It is worthwhile, therefore, to consider how Americans view the industry.

Public attitudes toward the chemical industry's compliance with environmental rules have become more critical in the past five years. The number of people who agree that the industry has done a poor job of observing laws and guidelines on air pollution has almost doubled, rising from 29% in 1974 to 50% in 1978. During the same period, the proportion believing the industry is doing a poor job in complying with water pollution controls has increased from 44% to 54%.

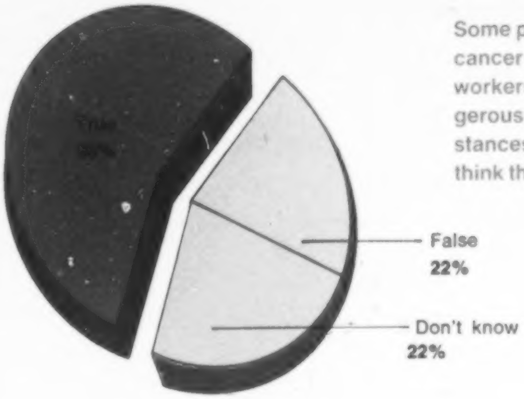
To understand why the chemical industry is singled out as an environmental polluter and a source of threatening substances, consider how the public views pollution. For the past several years, the Yankelovich, Skelly, and White "Corporate Priorities" studies have asked about air pollution. Data from these studies show that the public is increasingly concerned not only about the irritation and discomfort caused by polluted air but also about the health threat it poses to present and future generations. Moreover, waste from chemical plants is considered the most threatening water pollutant.

It should not be surprising, therefore, to find that chemicals also are seen as a cause of cancer. When the 1978 Cambridge study asked the public and chemical workers to choose the principal cause of cancer, chemicals came in second, although a remote second, to smoking, with occupational exposure placing a distant sixth. The data suggest that concern about chemicals is more about chemicals in the environment generally than in the chemical workplace in particular.

Nevertheless, when asked directly, both groups agree

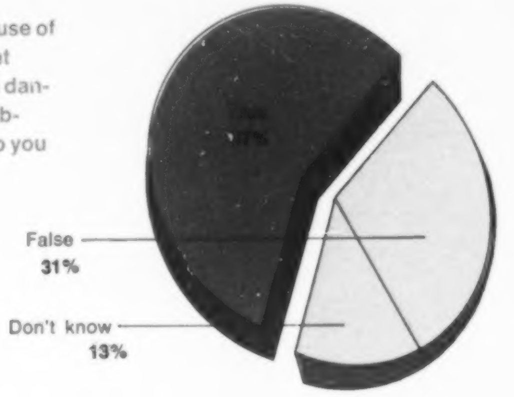
Majority thinks on-the-job exposure leads to cancer

General pubiic



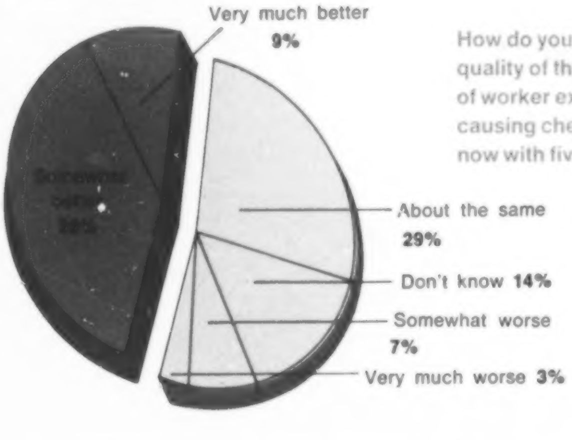
Some people say a key cause of cancer is the exposure that workers have on the job to dangerous cancer-causing substances and chemicals. Do you think this is true or false?

Chemical workers



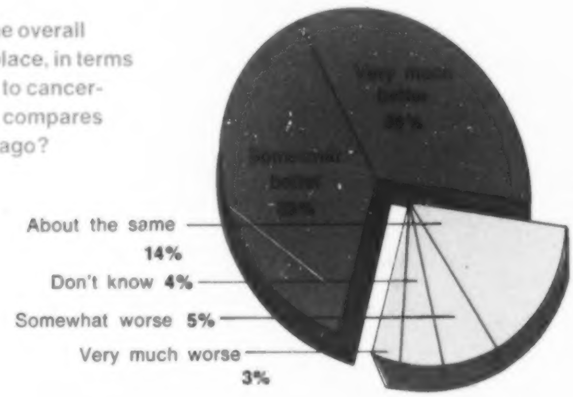
Workers think exposure to carcinogens has been reduced

General public



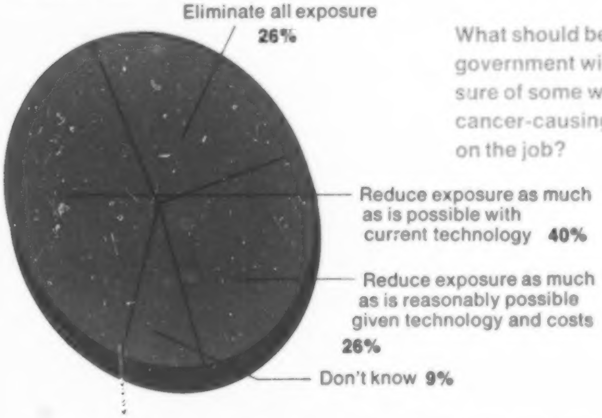
How do you think the overall quality of the workplace, in terms of worker exposure to cancer-causing chemicals, compares now with five years ago?

Chemical workers



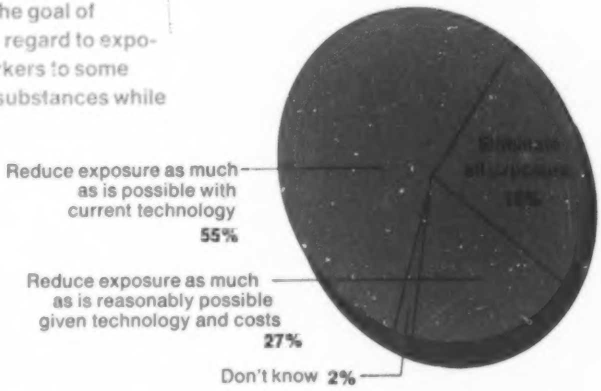
Majority would settle for less than zero on-the-job exposure to carcinogens

General public



What should be the goal of government with regard to exposure of some workers to some cancer-causing substances while on the job?

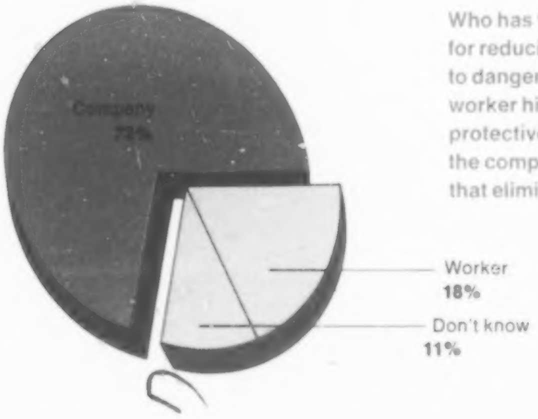
Chemical workers



Source: Cambridge Reports Inc., "An Analysis of Public and Worker Attitudes Toward Carcinogens and Cancer Risk"

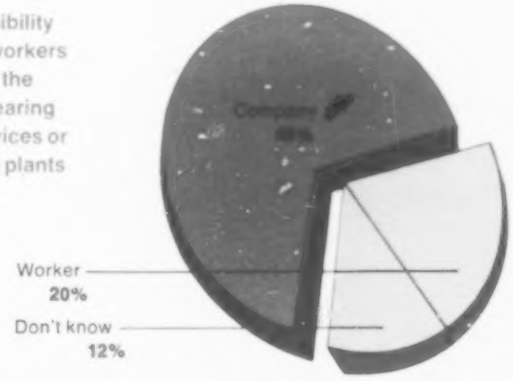
Companies are seen as responsible for worker safety

General public



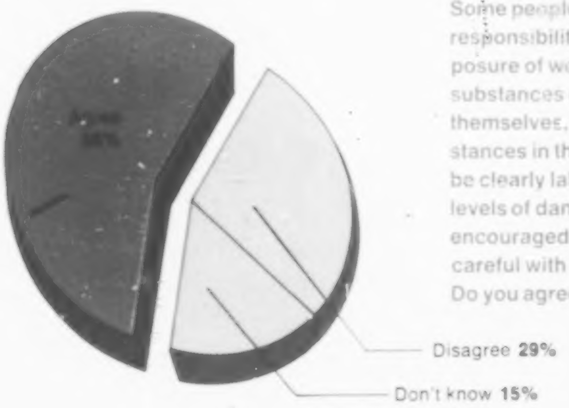
Who has the main responsibility for reducing exposure of workers to dangerous substances: the worker himself through wearing protective clothes and devices or the company by designing plants that eliminate exposure?

Chemical workers



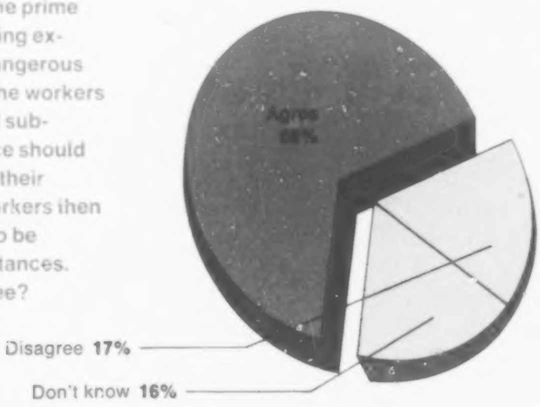
Adequate labeling considered a key to worker safety

General public



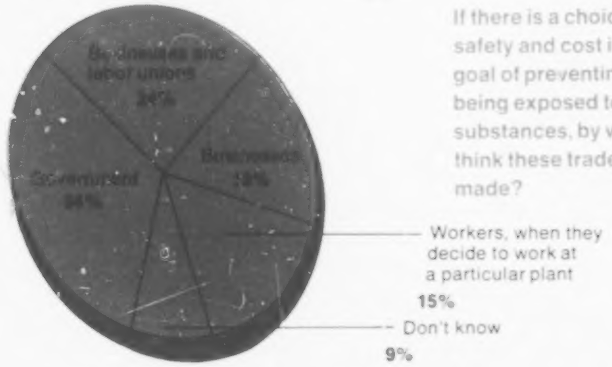
Some people say that the prime responsibility for reducing exposure of workers to dangerous substances rests with the workers themselves, and that all substances in the workplace should be clearly labeled as to their levels of danger and workers then encouraged or forced to be careful with these substances. Do you agree or disagree?

Chemical workers



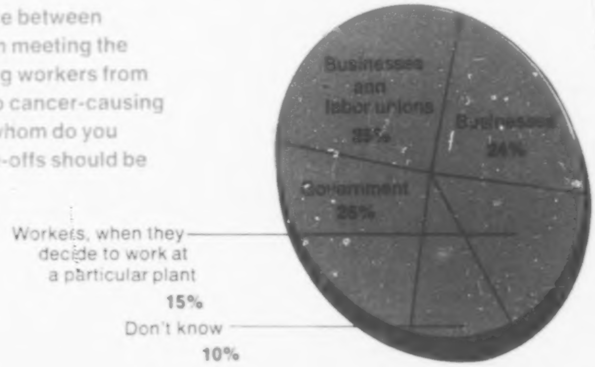
Opinions vary on who should make decisions on safety/cost trade-offs

General public



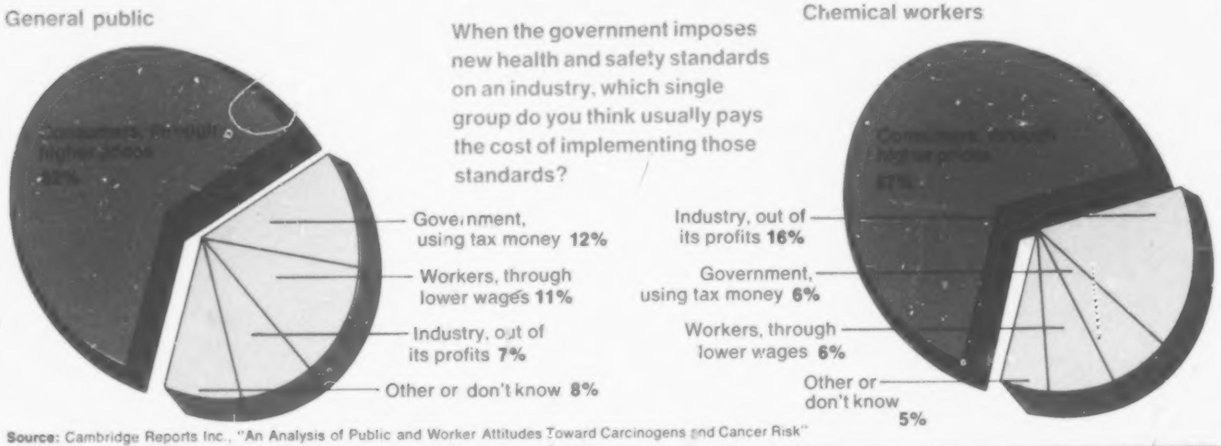
If there is a choice between safety and cost in meeting the goal of preventing workers from being exposed to cancer-causing substances, by whom do you think these trade-offs should be made?

Chemical workers



Source: Cambridge Reports Inc., "An Analysis of Public and Worker Attitudes Toward Carcinogens and Cancer Risk"

Public recognizes that costs of industrial safety fall on consumers



Source: Cambridge Reports Inc., "An Analysis of Public and Worker Attitudes Toward Carcinogens and Cancer Risk"

that a key cause of cancer is worker exposure to cancer-causing substances. Substantially more workers than public respondents, however, disagree with that proposition.

Three quarters of the general public and 82% of chemicals workers think that employer efforts to promote health and safety in the workplace are good to excellent. About a third of the public and almost half of chemical workers rate employer health and safety efforts excellent; less than a fifth of each group rates them fair or poor.

It should not be surprising, therefore, that the 1978 study found that two thirds of the public and 71% of chemical workers viewed employer efforts as about right and only a quarter of each group thought more effort was needed. Moreover, more than half of the public and more than two thirds of chemical workers believe that workplaces have become safer and more healthful in the past five years.

A substantial difference between public and worker perceptions of worker exposure to carcinogens during the past five years is evidenced by the Cambridge Reports data. Although only 48% of the public sees improvement in the quality of the workplace with regard to such exposure, 75% of chemical workers believes the quality is either somewhat better or very much better. Nowhere in the study does this difference show up more graphically, however, than when the respondents were asked whether or not industry is honestly trying to reduce worker exposure to cancer. Slightly more than a third of the public thinks that industry is trying to reduce such exposure; almost half thinks industry's only concern is making money. However, chemical workers' views ran in the opposite direction, with only 30% contending that making money is industry's sole concern, whereas 60% believes industry is indeed making an honest effort to reduce worker exposure to carcinogens.

These data, taken together, suggest that the chemical industry is increasingly seen not only as a polluter of the environment but also as a source of hazardous wastes that threaten public health. The public generally sees the chemical workplace as dangerous to workers. Chemical workers, however, tend to believe that risks in the workplace have declined in recent years and that employers are making a bona fide attempt to improve occupational health and safety, especially insofar as carcinogens are concerned.

At the heart of the debate over occupational safety standards affecting exposure to carcinogens is the issue of levels of exposure. On the one hand, some argue that because the level at which biologically active compounds cause cancer is not known, any exposure to such compounds should be eliminated. On the other hand, others contend that such a "zero exposure" standard is both unreasonably stringent and economically too costly, so that more realistic standards should be set.

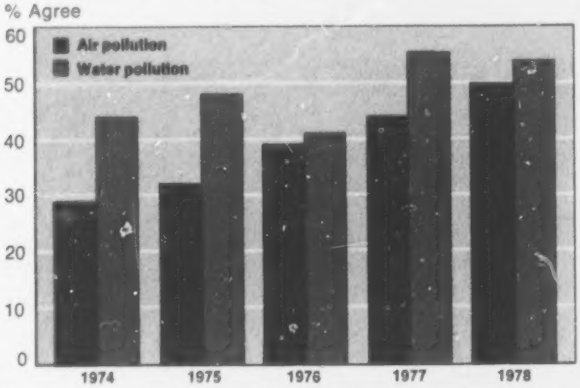
Given a choice of exposure standards, only about a quarter of the public and a sixth of chemical workers want zero exposure; 40% of the public and 55% of chemical workers would accept a reduction of exposure only to the level achievable with current technology. Indeed, 60% of the public and 81% of chemical workers interviewed in the 1978 study believe zero exposure is not possible.

It is frequently asserted that if consumers only knew the costs of regulation, they would oppose attempts to regulate industry. Therefore, public and worker understanding of the cost consequences of health and safety standards was examined in the 1978 study. About two thirds of both the public and chemical workers understands that the cost of implementing new health and safety standards is passed on to consumers in the form of higher product prices. Nevertheless, about the same proportion of both groups would accept higher prices to eliminate cancer risks.

There is no question that the chemical workplace is filled with potential hazards, such as scalding or corrosive liquids, irritating or toxic gases, and poisonous dusts. To protect workers from these substances, the chemical industry has adopted a number of effective safeguards. Equipment is designed to minimize the exposure of workers to the materials or vapors they contain. Protective gloves, clothing, masks, and goggles are provided in areas where exposure is likely. Most important of all, workers are trained in safety precautions, in the proper use of plant equipment, and in the use of protective clothing and equipment. Moreover, the use of such precautions and protective gear is required by plant rules, enforced by plant foremen, and supported by frequent retraining.

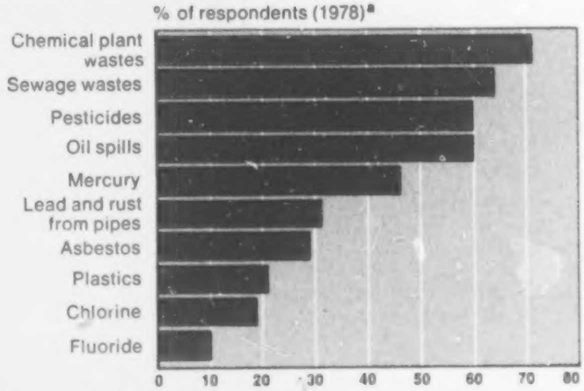
Nevertheless, a substantial question exists over whether the primary responsibility for protection of workers lies with the worker or with the employer. Central to the argument is the question of exposure standards. If responsibility for worker safety lies with the employer, then equipment must be designed and in-

Public is more critical of chemical industry compliance with pollution standards...



Do you think the chemical industry has done a poor job of observing laws and guidelines on air or water pollution?

...and thinks wastes from chemical plants are most hazardous water pollutant



When you think about potential hazards of water pollution, which pollutants do you think are the biggest?

[a] Respondents could select more than one pollutant. **Source:** Yankelovich, Skelly & White Inc.

stalled that reduces exposure to virtually zero levels. On the other hand, if responsibility lies with the worker, he or she can share in reducing exposure to potentially harmful chemicals by wearing protective clothing.

In the 1978 study, both public and worker samples overwhelmingly agreed that the employer bears the principal responsibility for protection of plant workers; only about a fifth of each group believed primary responsibility lies with the worker.

Even so, chemical workers in discussing plant safety frequently express the view that information on hazards is the key to worker safety. Workers contend that if potentially hazardous substances in the plant are adequately labeled, they themselves can take adequate precautions. The 1978 study, for example, indicates that a majority of the public and two thirds of the workers agree that, with appropriate labeling, responsibility for protection also lies with the worker.

Both of these issues involve trade-offs between worker safety and employer costs. Central to the debate is the question of who should decide how those trade-offs should be made. A variety of options are available. Since the workplace is under the control of the employer, the employer is one of those who can make the decision. Other potential decision makers are labor unions, the workers themselves, or federal and state agencies. Letting a government agency make the decision is the option selected by about a third of the public; workers' selections are about equally divided among business, business with labor unions, and a government agency. However, no very clear preference emerges. Indeed, 43% of the general public and 49% of the workers prefer that business participate, at least to some extent, in the decision regarding trade-offs between cost and safety.

It is evident, therefore, that both the public and chemical workers believe that responsibility for the safety of individual workers lies with the employer. There is less consensus whether that responsibility can be met by providing plants and equipment that minimize exposure or by clearly labeling hazardous material so that workers can don protective clothing and equipment. Accordingly, one could expect that both expedients will be examined.

The chemical industry appears to face growing problems in the national debate over cancer policy. On the other hand, it seems unlikely that press coverage of cancer issues, which has been increasing during the past decade, will abate. In such coverage, the chemical industry is rarely, if ever, shown in a favorable light.

The public has come to see chemicals and the chemical industry as threatening its health and the health of its posterity. To the extent such views continue, it is reasonable to predict that legislation and regulations imposing adverse and, perhaps, unreasonable performance standards on the industry's products and behavior will continue.

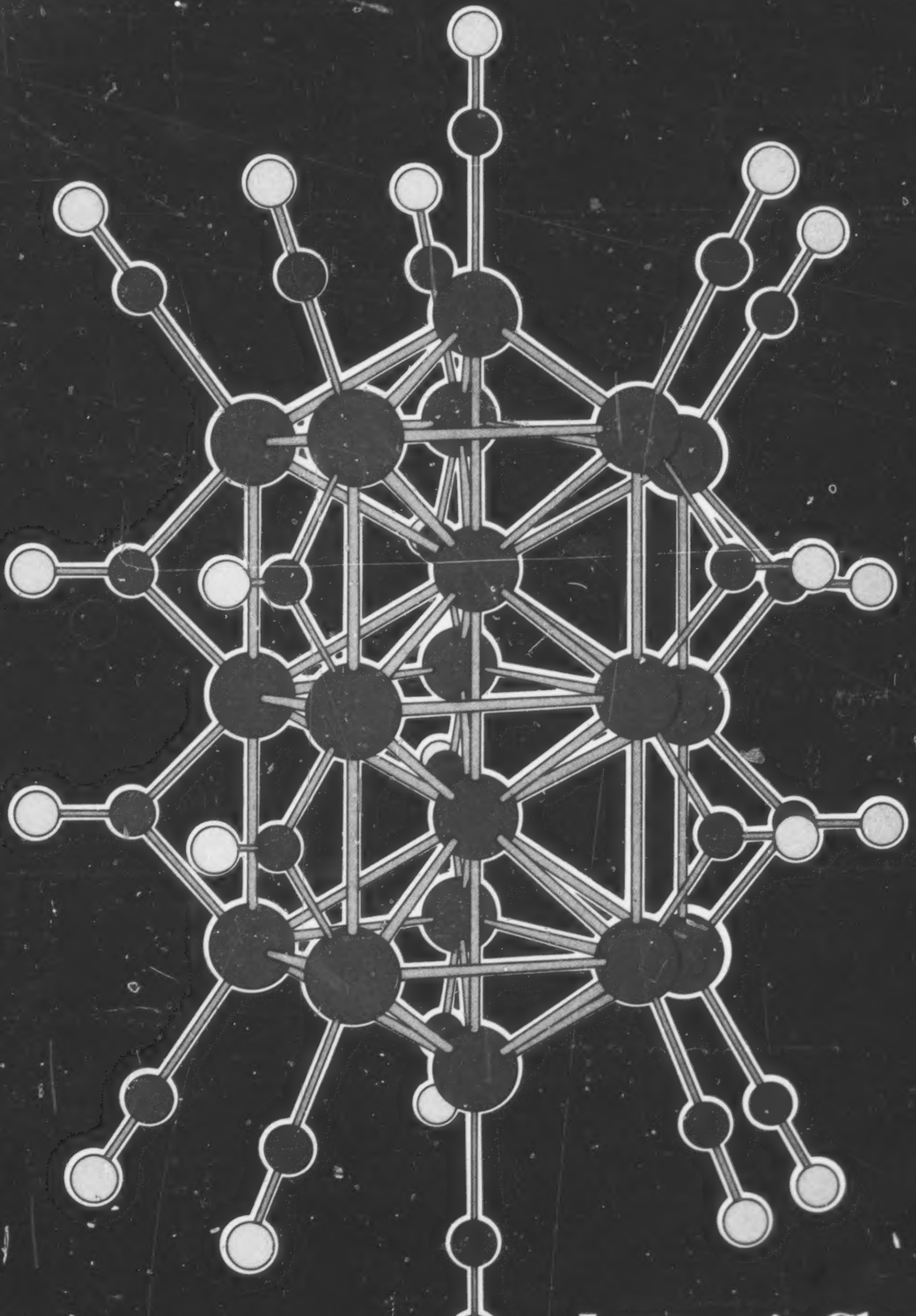
Against such a dark future, a ray of hope can be found. There also seems to be strong support for the chemical industry among its labor force. More than 1 million workers are employed in the chemical and allied products industry. This is a potentially powerful constituency for the industry in the coming debate about cancer policy.

It is likely that the debate will occupy the attention of policy makers, particularly public-interest groups, and the public itself for much of the coming decade. How well the chemical industry fares in this debate will depend not only on how well it controls pollution and workplace hazards, but also on how well it is perceived to control them. How successfully the chemical industry will avoid further imposition of onerous and excessive regulation will depend on how well it is represented in the debate by its constituencies. ☐

Rene D. Zentner is manager of Shell Oil's corporate studies department, which conducts surveys and does market research to improve the quality of Shell's decisions. He previously had held positions in Shell's patent and licensing organization, its transportation and supplies organization, and its planning and economics group. Zentner was graduated from Stanford University in 1944 with a degree in engineering chemistry and received a law degree from the University of California, Berkeley, in 1957. Prior to joining Shell, he worked for Du Pont, a San Francisco law firm, and Tracerlab. He has written extensively on legal and technical subjects. At present, also, he is adjunct associate professor at the Bates College of Law of the University of Houston.

Chemical earnings rise substantially but profit margins level off Page 10

Chemical & Engineering NEWS



Inorganic Chemistry

A C&EN Science Update Page 30

November 12, 1979
Volume 57, Number 46
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Chemical & Engineering NEWS

Cover: Metal cluster tetraanion, $[Pt_{19}(CO)_{12}(\mu\text{-}CO)_{10}]^{-4}$, in which platinum atoms are represented by magenta, carbon by blue, and oxygen by white

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- ***Chemical workers union** asks that production and use of Oryzalin herbicide be stopped, citing high incidence of birth defects among workers' children.* ***Page 6***
- ***Nuclear Regulatory Commission** suspends licensing for operation or construction of nuclear power plants, aims to focus on improving reactor safety.* ***Page 7***
- ***Study confirms earlier findings** that carbon dioxide is building up in the atmosphere through burning of fossil fuels, slash-and-burn agriculture.* ***Page 7***
- ***Santa Fe International,** oil drilling and construction firm, will acquire California-based C. F. Braun, engineering and construction company.* ***Page 8***
- ***Two big boosts in potash production** are under way: Potash Corp. of Saskatchewan will expand in Canada; Arab Potash Co. on the Dead Sea in Jordan.* ***Page 8***
- *γ **-Substance,** a natural compound purified from human urine, binds to the same brain cell receptors as do the antianxiety drugs, Danish scientists find.* ***Page 8***

Business

- ***U.S. chemical industry sales and earnings** continued strong in the third quarter although profit margins averaged only 6.1%; overseas business accounted for the strong showing of some firms.* ***Page 10***

Government

- ***Proposed materials policy bill** nixed by the White House on grounds that objectives are being met, but Congressional sponsors favor more structured approach.* ***Page 22***

Science

- ***The eye sees color** because the spectrum of the 11-cis-retinal molecule is changed by precisely located negative charges on amino acids of attached proteins.* ***Page 25***
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- ***Recent advances in inorganic chemistry** include new mechanism for olefin dimerization reactions based on metallacycle intermediate, insight into nitrogenase catalysis, research on amorphous materials.* ***Page 30***

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- ***Fostering innovation** must be national priority, ACS president Gardner Stacy tells federal hearing; gives society's patent law revision recommendations.* ***Page 35***

Chemical profits extend large gains

Third quarter was another big one for U.S. chemical firms with earnings up 30%, sales 25%; profit margins, however, are flattening out

William J. Storck
and William F. Fallwell
C&EN, New York

The third quarter saw another big earnings increase for U.S. chemical companies, extending excellent gains for the year. This time earnings were up an average 30% from the comparable quarter a year ago, and sales increased 25%. For the first three quarters, earnings rose 32% and sales increased 22%.

However, the latest earnings increase made it against an increasing drag. Holding earnings back, according to the companies, were a depressed automobile market, a downturn in synthetic fibers demand, and high raw materials costs. Counterbalancing were the generally high level of market activity and chemical plant use, good performance in petrochemicals and agricultural chemicals, and roaring business abroad.

Fortunately, for the third quarter, the pluses outweighed the minuses. But with a little shift the other way, earnings would have trailed sales' rate of increase, driving profit margins down.

As it is, the 6.1% average profit margin for the 40 largest basic chemical companies, although slightly ahead of last year's third quarter, is lower than it has been since fourth-quarter 1978.

Even more telling is the average profit margin of 5.8% chalked up by the 19 largest companies in C&EN's survey in the third quarter. This is the lowest reading for this group since the fourth quarter of 1977, when it was 5.4%. Thus, the industry's overall profitability is being kept up by smaller, more specialized firms.

These companies, ensconced in less diverse markets, include some with continuously lofty profit margins—International Flavors & Fragrances, Lubrizol, and Nalco Chemical.

However, other small companies are currently at dizzy cyclical peaks of profitability. Two of these, Texasgulf and Freeport Minerals, accounted for most of the smaller-company group's increase in profitability. Without these two companies, profit margins among the smaller firms would have averaged about 6.4% in the third quarter. This would have sent profitability for the entire list of 40 companies down to 5.9%, about the same as profitability was in third-quarter 1978.

During the third quarter, overseas business helped earnings a lot, just as it did in the second quarter. G. James Williams, financial vice president of Dow Chemical, says, "Business on a global basis has continued strong despite some slight evidence of a slackening in demand in the U.S." Williams says that for the first time in Dow's history, "non-U.S. sales are running more than 50% of the total for the company. Because of this geographic mix, any slowdown in the U.S. will be cushioned by expanding sales in other countries, both in production there and with exports from the U.S."

William H. Bricker, chief executive officer of Diamond Shamrock, also praises the foreign situation: "Specialty chemicals have performed well in the third quarter, particularly in Europe, where they have not only made up for the year's slow start, but are ahead of both expectations and 1978 performance to date."

However, other economic factors are beginning to undercut overall earnings gains. Raw material prices continued to squeeze producers during the third quarter. Edwin E. Tuttle, chairman and chief executive officer of Pennwalt, says, "We have not been able to raise prices to the same extent that our costs have risen. Total group earnings [before taxes and corporate expenses] therefore were

Chemical industry leaders for third-quarter 1979 . . .

Sales			Earnings		Profitability	
Rank		$ Millions		$ Millions[a]	Earnings as % of sales	
1	Du Pont	$3133.2	Du Pont	$234.0	Freeport Minerals	21.5%
2	Dow Chemical	2426.4	Dow Chemical	198.4	Texasgulf	16.7
3	Union Carbide	2325.7	Union Carbide	138.6	International Flavors	14.9
4	Monsanto	1496.7	Monsanto	82.1	Lubrizol	13.8
5	W. R. Grace	1278.6	W. R. Grace	57.3	Big Three Industries	12.1
6	Allied Chemical	1250.6	Hercules	41.4	Nalco Chemical	10.8
7	American Cyanamid	782.0	Diamond Shamrock	37.1	Dow Chemical	8.2
8	Celanese	778.0	Celanese	37.0	Mallinckrodt	7.8
9	Diamond Shamrock	606.0	American Cyanamid	35.7	Du Pont	7.5
10	Hercules	605.0	Texasgulf	31.9	Air Products	7.5

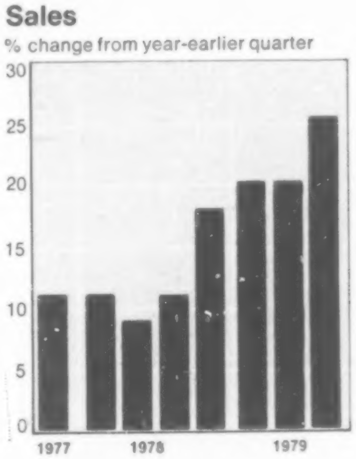
. . . and for first nine months of 1979

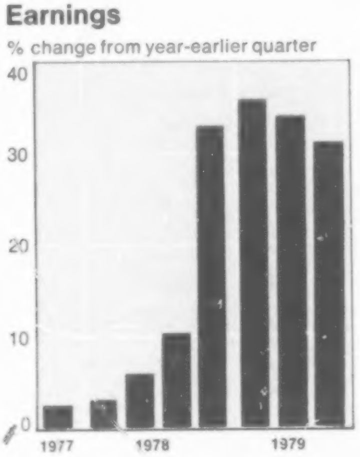
Sales			Earnings		Profitability	
Rank		$ Millions		$ Millions[a]	Earnings as % of net sales	
1	Du Pont	$9395.3	Du Pont	$707.7	Freeport Minerals	20.5%
2	Dow Chemical	6808.1	Dow Chemical	589.6	International Flavors	15.7
3	Union Carbide	6780.2	Union Carbide	413.7	Texasgulf	13.3
4	Monsanto	4647.3	Monsanto	303.4	Lubrizol	12.3
5	W. R. Grace	3781.1	W. R. Grace	153.3	Big Three Industries	12.1
6	Allied Chemical	3034.1	American Cyanamid	119.6	Nalco Chemical	11.1
7	Celanese	2332 0	Diamond Shamrock	119.6	Royster	10.9
8	American Cyanamid	2330.0	Hercules	117.7	Dow Chemical	8.7
9	Hercules	1749.0	Celanese	114.0	International Minerals	8.3
10	Diamond Shamrock	1700.0	Allied Chemical	108.2	Stauffer Chemical	8.3

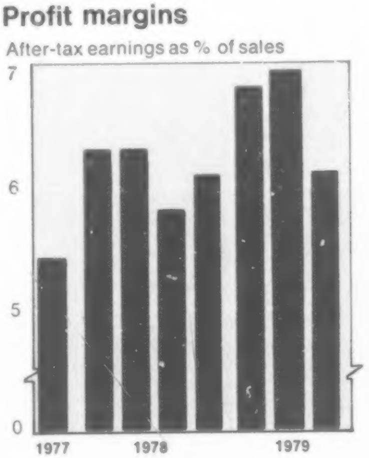
[a] After taxes. **Note:** For basic chemical companies with half or more of their sales in chemicals.

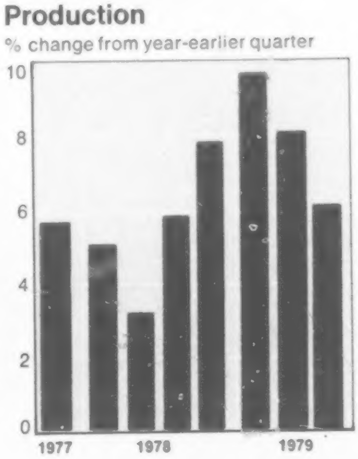
Chemical Industry 1979 Third Quarter

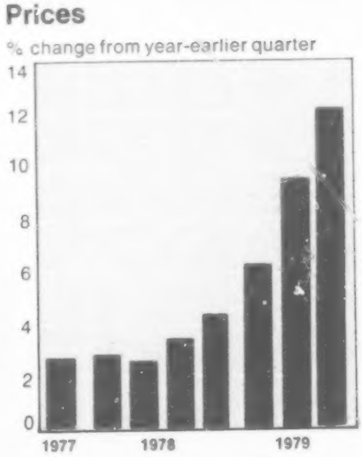
- **Sales shot up another 25%**
- **Earnings gains slowed**
- **Profit margins dropped**
- **Production rose 6.1%**
- **Prices jumped 12.2%**


Sales
% change from year-earlier quarter

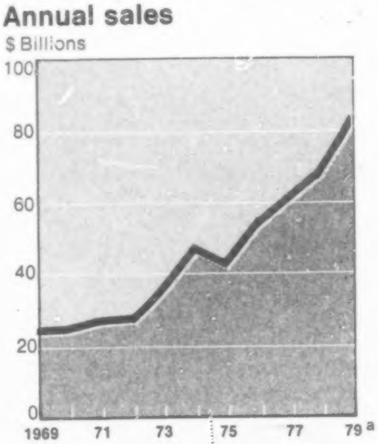

Earnings
% change from year-earlier quarter

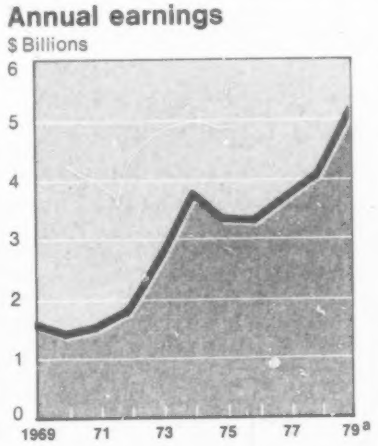

Profit margins
After-tax earnings as % of sales

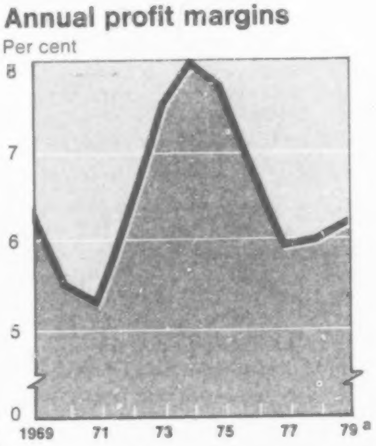

Production
% change from year-earlier quarter


Prices
% change from year-earlier quarter

For the full year, momentum from the first nine months likely will carry sales to 22% increase; earnings are expected to be up 28%; profit margins likely will be 6.2%


Annual sales
$ Billions


Annual earnings
$ Billions


Annual profit margins
Per cent

a C&EN estimates. **Note:** All sales, earnings, and profit margin data are based on the combined performance of the 40 largest basic chemical makers listed on page 12.

Third-quarter earnings were up 30% for chemical firms, but profit margins fell for most

	THIRD-QUARTER 1979						NINE-MONTHS 1979			
	Sales	Earnings	Change from 197[illegible]		Profit margin[a]		Sales	Earnings	Change from 1978	
	($ million)		Sales	Earnings	1979	1978	($ millions)		Sales	Earnings
Du Pont	$3,133.2	$234.0	17.9%	13.9%	7.5%	7.8%	$9,395.3	$707.7	18.9%	26.5%
Dow Chemical	2,426.4	198.4	44.9	29.3	8.2	9.2	6,808.1	589.6	34.3	35.0
Union Carbide	2,325.7	138.6	14.5	71.7	6.0	4.1	6,780.2	413.7	17.3	55.3
Monsanto	1,496.7	82.1	26.1	75.4	5.5	3.9	4,647.3	303.4	25.1	17.3
W. R. Grace	1,278.6	57.3	22.4	42.5	4.5	3.8	3,781.1	153.3	17.5	17.5
Allied Chemical	1,250.6	19.2	70.0	−42.9	1.5	4.6	3,034.1	108.2	35.6	−4.7
American Cyanamid	782.0	35.7	14.8	−1.0	4.6	5.3	2,330.0	119.6	14.2	6.8
Celanese	778.0	37.0	20.0	12.0	4.8	5.1	2,332.0	114.0	21.0	48.0
Diamond Shamrock[d]	606.0	37.1	32.3	25.0	5.3	6.5	1,700.0	119.6	30.8	29.0
Hercules	605.0	41.4	23.0	23.2	6.8	6.6	1,749.0	117.7	22.0	49.9
National Distillers	491.0	26.2	10.8	6.9	5.3	5.5	1,600.0	88.8	23.1	16.7
Williams Cos.	442.2	11.9	25.7	561.1	2.7	0.5	1,389.9	46.0	20.2	62.5
Ethyl Corp.	442.0	28.0	23.0	21.0	6.3	6.5	1,225.9	75.5	18.0	14.9
Olin	428.1	10.8	10.0	−41.0	2.5	4.7	1,337.1	55.6	16.1	15.6
Rohm & Haas	391.9	26.2	30.2	88.5	6.7	4.6	1,202.7	72.5	27.3	82.7
International Minerals	387.1	28.7	22.9	21.1	7.4	7.5	1,199.0	91.5	13.7	7.4
Air Products	347.8	26.2	26.4	33.7	7.5	7.1	954.3	75.6	19.3	29.7
Stauffer Chemical	312.5	11.0	15.7	−33.3	5.0	6.1	1,156.4	95.9	15.2	4.0
Cabot[e]	—	—	—	—	—	6.3	—	—	—	—
Pennwalt	266.6	11.5	17.7	12.7	4.3	4.5	796.0	38.1	15.5	10.4
Witco Chemical	247.5	10.8	24.4	20.0	4.4	4.5	705.6	32.6	30.3	36.4
Akzona	239.1	4.4	16.0	33.2	1.8	1.6	736.8	18.7	14.4	22.2
Reichhold Chemicals	221.3	1.3	15.6	−60.6	0.6	1.7	652.4	9.7	15.3	−17.8
Lubrizol	192.1	26.5	23.4	13.2	13.8	15.4	542.4	66.8	24.3	13.8
Texasgulf	191.3	31.9	21.7	149.2	16.7	8.1	739.9	98.5	33.2	128.0
Ferro	153.8	8.0	22.4	40.8	5.2	4.5	435.7	22.2	20.4	17.5
Thiokol	149.1	9.1	−1.1	50.4	6.1	4.0	478.9	26.5	19.8	55.9
Nalco Chemical	146.9	15.9	21.0	16.0	10.8	11.3	420.4	46.8	22.0	21.0
Big Three Industries	131.7	16.0	19.4	11.1	12.1	13.1	376.2	45.7	19.6	10.9
Freeport Minerals	129.5	27.8	76.9	291.5	21.5	9.7	357.4	73.4	60.5	314.7
International Flavors	103.7	15.5	14.6	9.9	14.9	15.6	317.2	49.9	13.5	13.4
Mallinckrodt	95.6	7.5	10.4	19.0	7.8	7.3	293.9	23.2	11.7	19.6
Liquid Air	94.7	6.4	26.6	33.3	6.8	6.4	270.4	18.4	17.9	18.7
Crompton & Knowles	55.7	1.5	2.4	7.1	2.7	2.6	178.9	4.6	12.2	17.9
Royster	47.2	1.0	98.3	f	2.1	f	220.4	24.0	40.2	485.5
Petrolite	45.1	2.6	6.8	−31.6	5.8	9.0	135.8	11.0	10.9	0.9
First Mississippi	44.1	2.3	51.5	f	5.2	f	150.8	9.3	31.4	220.1
Beker Industries[e]	—	—	—	—	—	f	—	—	—	—
Stepan Chemical	37.7	0.8	30.9	19.3	2.2	2.4	108.8	4.0	20.6	14.8
Virginia Chemicals	32.2	0.7	22.4	49.1	2.0	1.7	98.7	4.2	19.0	33.0
Total 19 largest companies[g]	**$18,191.4**	**$1061.3**	**25.9%**	**28.7%**	**5.8%**	**5.7%**	**$53,418.4**	**$3,386.3**	**21.8%**	**29.5%**
Total 19 other companies[g]	**$2,358.3**	**$190.0**	**21.0%**	**40.6%**	**8.1%**	**6.9%**	**$7,220.6**	**$589.5**	**24.8%**	**50.6%**
GRAND TOTAL[g]	**$20,549.7**	**$1251.3**	**25.3%**	**30.4%**	**6.1%**	**5.9%**	**$60,639.0**	**$3,975.8**	**22.1%**	**32.2%**

a After-tax income as percentage of net sales. b Fully diluted before nonrecurring items and extraordinary charges for continuing operations. c As of Oct. 31. d Includes nonrecurring

just barely ahead of a year ag spite of the 18% sales increase." After-tax earnings at Pennwalt increased 12% because of a lower effective tax rate, Tuttle says.

Hercules president Alexander F. Giacco says that during the third quarter, energy and raw material costs escalated rapidly and were substantially above those of the first half of the year.

The slowing in large-durables markets also pulled down earnings. Williams says that the only significant slowdown at Dow was in products associated with the auto industry, principally acrylonitrile-butadiene-styrene resins and polyurethane chemicals.

William S. Sneath, chairman and chief executive officer at Union Carbide, concurs. "Sales volume of certain product lines related to the automotive and steel industries began declining toward the end of the third quarter," he says.

John D. Macomber, president and chief executive officer of Celanese, points to additional weaknesses. "Sales of polyester textile filament and various plastics and specialty products were held back by declining consumer purchases of soft goods, automobiles, and housing." Macomber adds that these markets "plus a cost/price squeeze in polyester textile filament, led to the [10 cents a share] loss in the U.S. polyester/nylon business." Akzona's fibers division,

NINE-MONTHS 1979 Profit margin 1979	 1978	Earnings per share[b] 2nd qtr.	 Recent 12 months	STOCK MARKET DATA Stock price[c] Oct. 31	 Recent 12 months High	 Low	 Price/earnings ratio Oct. 31	 Annual indicated dividend	 Dividend yield, % of price
7.5%	7.1%	$1.62	$6.65	$38¾	$45⅞	$37	5.8%	$2.00	5.2%
8.7	8.6	1.09	4.01	29¾	34⅞	24⅜	7.4	1.60	5.4
6.1	4.6	2.11	7.87	39¼	44½	33⅝	5.0	3.00	7.6
6.5	7.0	2.27	10.69	55¼	62	45	5.2	3.40	6.2
4.1	4.1	1.24	4.25	35⅛	41¼	25⅝	8.3	2.05	5.8
3.6	5.1	0.64	4.53	42⅞	48¼	27⅝	9.5	2.00	4.7
5.1	5.5	0.75	3.42	30	32⅛	23¾	8.8	1.60	5.3
4.9	4.0	2.41	9.71	41¾	48¾	38½	4.3	3.20	7.7
7.0	7.2	0.70	3.26	24¾	27½	19	5.8	1.60	6.5
6.7	5.5	0.93	3.36	19⅜	22¾	14½	5.8	1.10	5.7
5.6	5.7	0.75	3.53	25¼	30⅜	18	7.2	1.80	7.1
3.3	2.4	0.44	1.64	22	24⅞	14	13.4	1.00	4.5
6.2	6.3	1.38	4.69	24¾	30	19⅜	5.3	1.35	5.5
4.2	4.2	0.51	2.93	17⅛	25	15⅜	5.2	1.00	5.8
6.4	4.7	2.03	7.00	41¾	47¾	30½	6.0	2.00	4.8
8.3	8.1	1.82	6.60	54½	61½	34	8.3	3.00	5.5
7.9	7.3	0.92	3.45	28⅜	35⅝	23⅛	8.2	0.80	2.8
8.3	9.2	0.25	3.69	19⅝	25	19	5.3	1.10	5.6
—	6.5	—	—	38¾	50	26⅝	6.0	1.60	4.1
4.8	5.0	1.15	4.87	31⅜	35⅞	30½	6.4	2.20	7.0
4.6	4.4	1.13	4.54	25⅜	29¼	18⅛	5.6	1.40	5.5
2.5	2.4	0.25	2.01	12½	17⅛	11¼	6.2	0.80	6.4
1.5	2.1	0.07	1.49	12	16½	10¾	8.1	0.74	6.2
12.3	13.5	1.36	4.37	48⅝	49¾	39¼	11.1	1.60	3.3
13.3	7.8	0.87	2.69	26	33	18	9.7	1.20	4.6
5.1	5.2	1.06	4.09	20⅝	29⅜	18¼	5.0	1.20	5.8
5.5	4.3	1.57	5.72	39¼	46	27¼	6.9	1.55	3.9
11.1	11.2	0.69	2.92	30⅛	35⅝	24⅜	10.3	1.36	4.5
12.1	13.1	0.80	3.05	38¼	44½	29¾	12.5	0.88	2.3
20.5	7.9	1.33	3.94	39½	50⅜	30	10.0	1.20	3.0
15.7	15.7	0.43	1.67	19⅛	25⅝	18½	11.5	0.80	4.2
7.9	7.4	0.77	3.29	28¼	33¼	26¼	8.6	1.00	3.5
6.8	6.8	0.60	2.31	25½	23¾	29	11.0	1.40	5.5
2.6	2.4	0.62	2.96	14⅝	18¼	12⅝	4.9	1.04	7.1
10.9	2.6	0.13	0.06	10	13⅜	3⅝	166.7	0.40	4.0
8.1	8.9	0.44	1.79	41	52½	34	22.9	1.08	2.6
6.2	2.5	0.27	1.83	19¼	22⅜	8	10.5	0.40	2.1
—	f	—	--	10	12⅜	2⅞	14.0	—	—
3.7	3.9	0.44	2.74	20⅞	23½	16	7.6	0.92	4.4
4.3	3.8	0.25	2.16	13	16½	13	6.0	0.62	4.8
6.3%	**6.0%**								
8.2%	**6.8%**								
6.6%	**6.1%**								

items. e Not all data available by press time. f Deficit. g Averages except for sales and earnings.

American Enka, also lost money on normal operations.

Agricultural chemicals were a bright spot. J. Peter Grace, president of W. R. Grace, says, "Selling prices for phosphate-based fertilizers, and also for nitrogen products, are above year-ago levels and show signs of continued strength." The two most improved smaller firms, Texasgulf and Freeport Minerals, got much of their profits acceleration from phosphate fertilizers.

Agricultural chemicals also did well at most nonchemical companies with a stake in this area, one of the most important chemical investment targets from outside the basic chemical industry. For example, Esmark's Estech business segment, which contains the company's chemical business, got an earnings boost "from a strong agricultural environment with better-than-expected planted crop acreage and increased fertilizer application."

The same phosphate fertilizer boom that catapulted earnings at Freeport Minerals and Texasgulf figured strongly in chemical earnings at Occidental Petroleum. The oil company's Hooker Chemical division benefited from higher fertilizer prices and the income from its first year of large-scale superphosphoric acid exports to the Soviet Union.

However, Hooker had trouble in other parts of its largely inorganic product spectrum that drastically

Profit margins still rise for most chemical producers in the oil industry

		3RD-QUARTER 1979						NINE-MONTHS 1979		
	% chemical sales	Sales[a]	Earnings[b]	Change from 1978		Profit margin[c]		Sales[a]	Earnings[b]	Change from 1978
		($ millions)		Sales	Earnings	1979	1978	($ millions)		Sales
OIL AND GAS COMPANIES										
Exxon[d]	8	$20,649.0	$1145.0	30%	118%	5.5%	3.3%	$59,055.0	$2930.0	26%
Mobil[d]	3	12,174.0	595.0	34	131	4.9	2.8	33,165.0	1436.0	24
Texaco	2	10,251.0	509.0	46	158	5.0	2.8	27,143.0	1149.6	30
Standard Oil of California	4	8,144.0	576.0	35	110	7.1	4.6	22,023.0	1335.0	24
Gulf Oil	9	6,736.0	416.0	33	97	6.2	4.2	18,410.0	956.0	26
Standard Oil (Ind.)	12	5,127.9	433.8	25	49	8.5	7.0	14,145.4	1184.1	17
Atlantic Richfield	9	4,378.7	320.4	28	45	7.3	6.5	11,627.1	822.9	23
Shell Oil	18	3,766.0	293.3	32	18	7.8	8.7	10,244.9	794.4	25
Continental Oil	6	3,500.0	214.5	41	103	6.1	4.4	9,300.0	592.1	32
Tenneco	9	2,806.0	132.0	33	28	4.7	4.9	7,989.0	411.0	27
Sun Co.	3	2,611.0	174.3	38	65	6.7	5.5	7,494.0	453.1	37
Occidental Petroleum	20	2,608.0	186.1	55	864	7.1	1.1	6,688.2	374.8	49
Phillips Petroleum	16	2,500.0	193.0	43	62	7.7	6.8	6,700.0	584.6	28
Union Oil	11	2,140.0	106.0	30	14	5.0	5.6	5,770.0	348.3	23
Standard Oil (Ohio)	6	2,100.0	366.2	62	191	17.4	9.7	5,600.0	735.1	52
Ashland Oil	15	1,940.0	53.0	13	−15	2.7	3.6	5,227.5	135.7	27
Cities Service	9	1,615.0	86.1	42	111	5.3	3.6	4,472.5	241.3	30
El Paso	10	836.0	38.5	62	60	4.6	4.6	2,187.8	110.4	51
Kerr-McGee	18	679.8	42.6	30	25	6.3	6.5	1,928.0	119.6	26
American Petrofina	14	427.8	27.8	43	467	6.5	1.6	1,129.7	55.4	34
DIVERSIFIED MANUFACTURERS										
General Electric	2	5,610.0	340.8	16	14	6.1	6.2	16,330.0	1026.3	15
Engelhard Minerals	2	4,234.3	105.3	59	185	2.5	1.4	10,898.7	211.9	71
U.S. Steel	7	3,225.0	81.3	16	−8	2.5	3.2	9,897.2	268.7	22
Procter & Gamble	3	2,663.9	185.7	17	11	7.0	7.3	7,458.3	469.0	14
Goodyear Tire & Rubber	11	2,021.9	29.2	7	−36	1.4	2.4	6,163.9	130.9	13
Eastman Kodak	20	1,995.7	285.8	14	20	14.3	13.6	5,441.2	706.1	16
Esmark	10	1,699.1	25.1	14	27	1.5	1.3	4,944.3	66.4	17
3M	15	1,422.0	174.3	16	14	12.3	12.5	4,073.0	488.0	17
Georgia-Pacific	8	1,385.0	85.0	15	9	6.1	6.5	3,836.0	257.0	19
Firestone Tire & Rubber	11	1,307.8	10.4	8	−35	0.8	1.3	3,865.4	77.8	10
Aluminum Co. of America	5	1,172.0	107.4	15	28	9.2	8.2	3,556.0	369.5	20
Borden	33	1,094.5	38.0	16	9	3.5	3.7	3,166.4	102.5	13
FMC	35	802.1	29.2	15	1	3.6	4.2	2,422.9	111.7	16
PPG Industries	32	784.3	56.3	11	23	7.2	6.5	2,290.0	163.8	11
B. F. Goodrich	36	742.9	16.2	15	6	2.2	2.4	2,212.9	67.1	16
Kaiser Aluminum	14	704.8	52.8	17	55	7.5	5.6	2,212.8	168.4	21
Pfizer	15	683.9	60.6	14	8	8.9	9.3	2,002.2	175.3	15
Northwest Industries	11	661.4	44.6	7	9	6.7	6.6	1,888.5	123.7	7
Borg-Warner	20	660.5	35.5	15	15	5.4	5.4	2,001.2	113.6	17
Merck	16	589.3	95.7	19	22	16.2	15.8	1,755.0	289.7	21
Uniroyal	19	563.0	−11.5	−12	f	f	f	2,001.4	−8.6	−1
General Tire & Rubber	10	554.1	20.8	−6	−29	3.8	5.0	1,675.6	66.2	7
NL Industries	30	531.1	30.7	13	38	5.8	4.7	1,610.7	77.4	17
Martin Marietta	12	530.4	54.1	16	21	10.2	9.8	1,491.4	140.7	19
Koppers	31	517.6	32.4	16	28	6.3	5.7	1,319.4	61.3	16

a Companies ranked by current quarter sales. **b** Before nonrecurring and extraordinary items for continuing operations, earnings per share fully diluted. **c** After-tax income as percentage of sales. **d** 1979 earnings include nonrecurring item. **e** Deficit in 1979. **f** Deficit.

NINE-MONTHS 1979			STOCK MARKET DATA							
Change from 1978			Earnings per share[d]		Stock price			Price-earnings ratio Oct. 31	Annual indicated dividend	Dividend yield, % of price
	Profit margin[c]			Recent		Recent 12 months				
Earnings	1979	1978	3rd qtr	12 months	Oct. 31	High	Low			
53%	5.0%	4.1%	$2.60	$8.55	57½	61¼	47½	7	$4.40	7.7%
81	4.3	3.0	2.80	8.34	49¼	56	36¼	6	3.00	6.1
119	4.2	2.5	1.87	5.56	27⅞	32⅛	22⅛	5	2.16	7.7
73	6.1	4.4	3.38	9.77	54½	62⅛	42⅝	6	3.20	5.9
74	5.2	3.7	2.13	6.19	33½	34¾	22¼	5	2.25	6.7
38	8.4	7.1	2.97	9.58	77	78¼	49⅜	8	3.00	3.9
41	7.1	6.1	2.60	8.53	72¾	76⅝	49⅛	9	2.80	3.8
28	7.8	7.6	1.90	6.44	47½	51¾	30¼	7	2.40	5.1
100	6.4	4.2	2.00	6.96	42¼	45½	24½	6	1.90	4.5
24	5.1	5.2	1.18	4.96	35⅞	39½	29	7	2.40	6.7
56	6.0	5.3	3.02	9.15	57½	70⅜	36⅜	6	3.00	5.2
[e]	5.6	[e]	2.23	3.24	24	27⅜	14⅞	7	1.25	5.2
33	8.7	8.4	1.25	4.45	43	46⅛	28⅞	10	1.40	3.3
35	6.0	5.5	1.22	4.98	43	49⅝	33	9	1.30	3.0
157	13.1	7.7	3.03	7.58	72½	78½	32½	10	1.60	2.2
12	2.6	2.9	1.66	5.04	33½	45½	31	7	2.00	6.0
77	5.3	3.9	3.11	10.67	74¼	80¼	50¾	7	3.60	4.8
54	5.0	4.9	0.81	3.12	19⅛	22¼	13⅜	6	1.32	6.9
53	6.2	5.1	1.64	6.78	57⅛	66½	41⅜	8	1.55	2.7
363	4.9	1.4	2.60	7.09	34⅞	38⅝	22⅝	5	2.50	7.2
18	6.3	6.1	1.50	6.11	48⅜	55⅛	45½	8	2.80	5.8
130	1.9	1.5	3.16	7.87	42¾	49¾	24¾	5	1.98	4.6
82	2.7	1.8	0.91	4.19	20⅛	26⅛	20⅛	5	1.60	8.0
12	6.3	6.4	2.25	7.22	74¼	89¾	72¾	10	3.40	4.6
−15	2.1	2.8	1.80	2.67	12¾	18⅞	12¾	5	1.30	10.2
24	13.0	12.1	1.78	6.43	49⅞	66⅞	49¼	8	2.40	4.8
17	1.4	1.3	1.20	4.27	27⅝	32	23⅜	6	1.84	6.7
17	12.0	12.0	1.48	5.51	50	66	48⅛	9	2.40	4.8
13	6.7	7.0	0.79	3.16	24¾	30⅜	24	8	1.20	4.8
50	2.0	1.5	0.18	1.70	8⅝	13⅞	8⅝	5	0.60	7.0
74	10.4	7.2	3.04	12.44	52⅜	60½	43⅝	4	2.80	5.3
0	3.2	3.7	1.17	4.19	25⅜	28⅛	24⅝	6	1.82	7.2
8	4.6	5.0	0.81	4.52	24⅝	[illegible]½	22	5	1.40	5.7
25	7.2	6.4	1.74	6.65	30¾	34¼	23⅛	5	2.00	6.5
38	3.1	2.6	0.95	5.26	18⅛	24	16⅛	3	1.44	7.9
51	7.6	6.1	1.20	4.67	18¾	22⅛	16⅜	4	1.20	6.4
14	8.8	8.8	0.83	3.22	34½	36¼	29	11	1.32	3.8
13	6.6	6.2	1.45	5.51	32⅝	37⅞	23	6	2.05	6.3
19	5.7	5.6	1.65	7.09	32⅞	37¼	26	5	2.30	7.0
23	16.5	16.2	1.27	4.79	66⅛	71⅝	53¾	14	1.90	2.9
[f]	[f]	0.1	−0.43	−0.25	4¼	8¼	3⅞	[f]	0	0
−23	4.0	5.4	0.89	4.04	20	27	19	5	1.50	7.5
28	4.8	4.4	0.90	3.02	27½	30½	17½	9	1.20	4.4
42	9.4	7.9	2.16	7.04	35¾	40⅜	26⅛	5	2.00	5.6
24	4.6	4.4	1.24	3.39	23¾	27⅜	17⅜	7	1.40	5.9

reduced the division's overall profit from third-quarter 1978. The biggest headache was chlorine and caustic soda, which the company says are still suffering from depressed prices and high energy costs.

However, other chlorine and caustic soda producers among both chemical and largely nonchemical companies note progress in the third quarter. PPG Industries, an important merchant seller, says demand was heavy. Diamond Shamrock calls the chlorine-caustic situation improved, and Pennwalt considers the market a turnaround.

Other inorganics drew mixed notices from the diversified company group. For example, FMC rates the third quarter good for natural soda ash and hydrogen peroxide. However, the company's long-running problems in phosphorus continued, with temporary shutdown of a major plant in Idaho after a power shortage caused by apparent sabotage of a large generator station.

In the organics sphere, the third-quarter star among nonchemical companies was petrochemicals in the oil industry. After-tax petrochemical profits more than doubled, on average, for leading companies (C&EN, Oct. 29, page 6) on only moderate physical volume increases. Prices were way up in both olefins and aromatics, and plant use was very high. In an extreme example, Gulf Oil's sales poundage of chemicals dropped 3% in the third quarter from a year earlier but its chemical profits jumped fivefold. The profit columns also got a major boost from Gulf's plastics. Plastics helped other oil companies, too.

Plastics were critical for profits in two other nonchemical industries, steel and rubber, both of which are trapped in a recessionary earnings drop in their principal markets. At U.S. Steel, chemicals made the best general improvement of any major operation and helped counterbalance the deficit in the company's steel operations.

Even more important were plastics' earnings, especially from polyvinyl chloride, at rubber companies. In fact, it's not an exaggeration to say that rubber companies' financial health in the third quarter depended on how much plastics and chemicals they had. At the most buffered company, B. F. Goodrich, chemicals dominated third-quarter earnings and allowed the company to post a small increase from third-quarter 1978.

However, at Goodyear and Firestone, which have proportionately less chemicals in their sales, earnings fell sharply this year. And at Uniroyal, even record chemical earnings could not save the company from another overall earnings loss caused by weak tire operations.

From here on, chemicals may not be able to save rubber and other company earnings as they did in the third quarter. Goodrich chairman John D. Ong says, "We expect that conditions will continue to deteriorate in the fourth quarter for our tire business. This will adversely affect the synthetic rubber operations in our chemical group. High interest rates will affect construction industry activity which may, in turn, reduce demand for that portion of polyvinyl chloride associated with new construction. Finally, despite evidence of a slowdown in the economy, we continue to experience rising costs for raw materials, energy, and labor."

Among basic chemical company executives, the outlook for the fourth quarter is cautious to optimistic. H. Barclay Morley, chairman of Stauffer Chemical, says that, assuming no significant decline results from general weakening in the economy, the outlook for the fourth quarter remains favorable for Stauffer, based on strong international business.

Claude Ramsey, president and chairman of Akzona, takes a middle road. Ramsey says, "The expected slowing of the economy has not yet had much impact on the various business areas [of Akzona], except in the case of American Enka, where it has been difficult to pass along cost increases." Concerning the fourth quarter, Ramsey says, "The general economy is so unsettled now that the outlook for the balance of the year is unclear."

Irving S. Shapiro, chairman of Du Pont, says, "Sharp increases in material and energy costs and softening in some areas of the U.S. economy makes it increasingly difficult to maintain the company's progress toward adequate profit levels. Nevertheless, Du Pont's performance during the first three quarters of the year showed good improvement over last year, and full-year results should reach an acceptable level, [barring] a sharp, sudden downturn in the economy."

Dow's Williams says that the company remains "confident that 1979 will be a good year. Sales should be approximately $9 billion and earnings for the year will exceed 1978's by at least 25%."

Diamond Shamrock's Bricker says, "Our previously announced 1979 earnings target now appears to be conservative. An earnings target of $175 million to $180 million appears to be attainable from operations, rather than the $170 million formerly estimated." ☐

CHECKOFF

NEW PLANTS

■ **Acrylonitrile**—Vistron subsidiary of Standard Oil (Ohio) plans 400 million lb-per-year plant costing more than $100 million at its new Green Lake, Tex., site. To be completed at end of 1981, unit will use Sohio's own technology. C-E Lummus subsidiary of Combustion Engineering will do the engineering, procurement, and construction supervision.

■ **Butynediol**—GAF plans $15 million plant of unspecified capacity at Seadrift, Tex., for this intermediate for butanediol. Completion scheduled for early 1981.

■ **Detergent alkylate**—Witco Chemical plans second unit at Carson, Calif., which will double capacity to 90 million lb a year. To cost $12 million, new unit will be part of larger expansion of alkylate-related facilities to be completed in early 1981.

■ **Ethyleneamines** — Dow Chemical plans to expand capacity at Freeport, Tex., from current 60 million lb per year to 100 million lb. Completion scheduled for 1982. This project is part of larger campaign to bring worldwide capacity to 160 million lb in 1982.

■ **MDI**—BASF Wyandotte has started construction on plant in Geismar, La., to make 150 million lb a year of diphenyl methane diisocyanate (MDI). Completion is scheduled for late 1981. C-E Lummus will do engineering for plant, which will use technology from parent BASF.

■ **Organotin**—M&T Chemicals plans plant near Mobile, Ala., with capacity of 10 million to 15 million lb a year of tetrabutyl and tetraoctyl tin. Target startup date is July 1981. Products are intermediates used to make other organotin compounds.

■ **Sodium sulfite**—Allied Chemical is expanding capacity at North Claymont, Del., from current 20,000 tons per year to 30,000 tons for technical-grade product. Completion scheduled by end of 1979. Expansion will use Allied's own technology.

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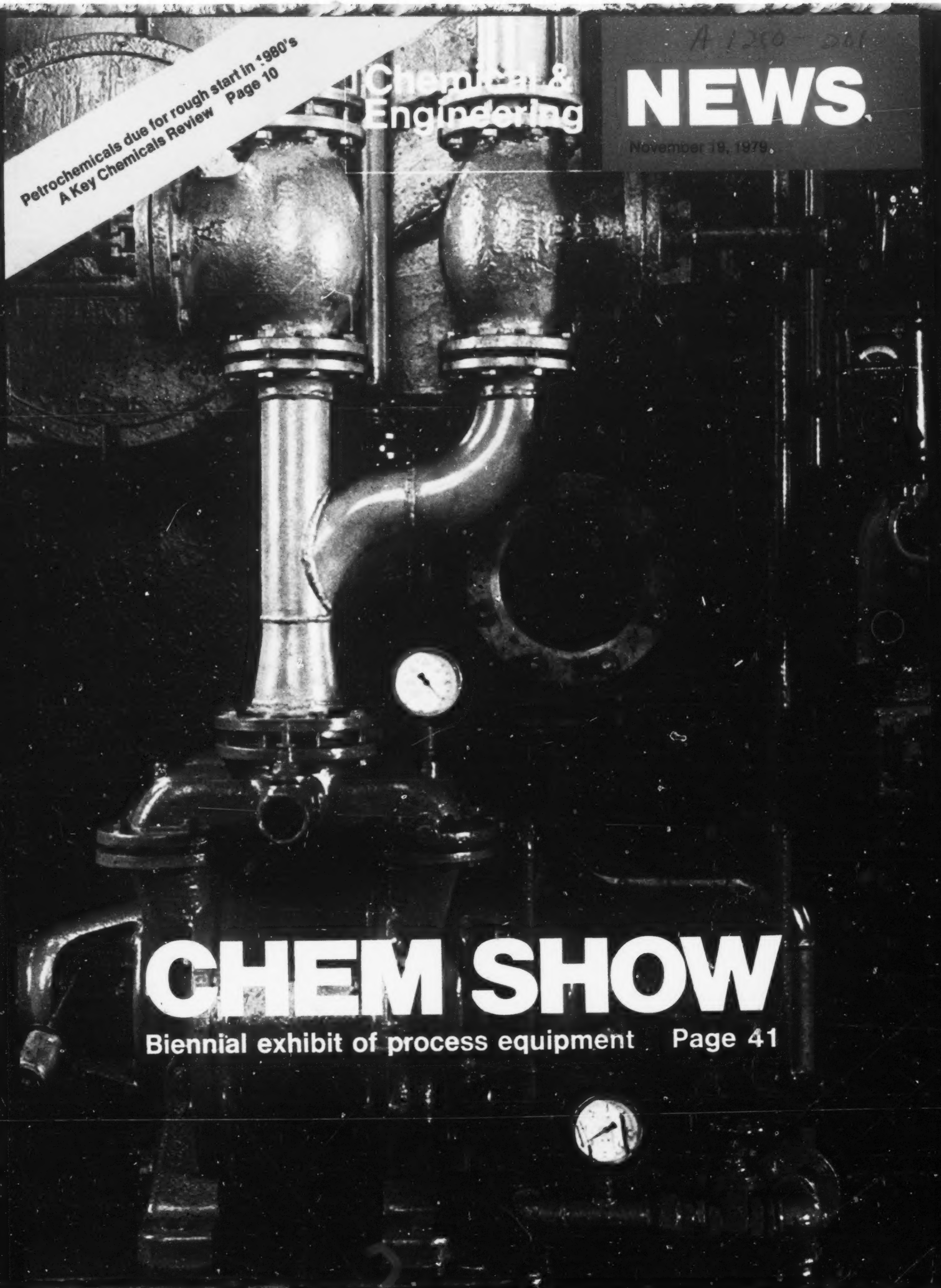
Chemical &
Engineering
NEWS
November 19, 1979

Petrochemicals due for rough start in 1980's
A Key Chemicals Review Page 10



CHEM SHOW

Biennial exhibit of process equipment Page 41

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Cover: Photo courtesy of BASF

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News of the Week

- ***Estimates of potential stratospheric ozone loss*** *due to chlorofluorocarbons in NAS report are almost double those of earlier figures; Du Pont cites British study that reaches different conclusions.* **Page 6**
- ***Monsanto's new gas-separation technology*** *employs Prism separator modules, single-ended bundles of tubular membranes made of coated polysulfones.* **Page 6**
- ***Albert C. Zettlemoyer*** *is ACS president-elect for 1980; Robert W. Parry and William J. Bailey re-elected directors-at-large; Gordon L. Nelson retains directorship in Region I; Bernard S. Friedman will represent members in Region V.* **Page 7**
- ***Three rail accidents*** *involving tank cars carrying hazardous chemicals led to evacuation of residents from Ontario, Florida, and Michigan cities.* **Page 8**
- ***Nuclear power industry executives,*** *troubled by NRC moratorium on licensing, cite remedial efforts already under way to solve technical problems, set up training programs for reactor operators.* **Page 8**

Business

- ***U.S. petrochemicals producers*** *expect only small financial gains in 1980 after surprisingly high production, profits in 1979; big worry is rising raw materials cost, as gasoline competes for feedstock.* **Page 10**

International

- ***Canadian chemical industry earnings recovery*** *continues in third-quarter 1979; combined earnings for four largest firms rose 173% above third-quarter 1978.* **Page 22**

Government

- ***Many public-interest activists,*** *attracted by Carter's environmental stand, have taken positions in the Administration with hopes of influencing policy decisions.* **Page 25**

Science

- ***The chemical complexity of the brain*** *becomes more and more apparent with the discovery of nerve cell peptides that may prove to be neurotransmitters.* **Page 30**

Chem Show

Exhibitors of industrial equipment *at the biennial exposition are concerned about the uncertainty of the business climate; namely, the effect of inflation and nonproductive investment on chemical industry capital spending plans.* **Page 41**

Books

- ***"Enterprise,"*** *an insider's story of torpid U.S. space shuttle program, carries message, reviewer says, that private enterprise, not government, should do it.* **Page 63**

Surge in petrochemicals due to subside

Small gains are in store in 1980 following surprisingly high production and profits in 1979; big worry next year is raw materials costs

This year turned out to be a fooler on the plus side for U.S. petrochemical producers. The main concern now is that 1980 doesn't wind up a fooler the other way.

A year ago, the major building-block petrochemicals showed distinct but not decisive signs of the explosion to come. Prices were well up in aromatics, exports for derivatives good all around, competition apparent from gasoline for raw materials.

However, the verdict at the time was that petrochemicals had too much unused plant capacity to translate these forces into major market gains, especially in profitability (C&EN, Nov. 20, 1978, page 12). This view underestimated the power of the business burst which followed.

The recession expected by many receded like a mirage in most markets in 1979. Instead, general business barreled along in most areas, except consumer durables such as automobiles and housing.

The swelling pace lifted petrochemical demand to twice the gain expected in the industry as the year began. For the five leading petrochemicals covered in the following pages—ethylene, propylene, butadiene, benzene, and *p*-xylene—U.S. production increased 10% in 1979 to a combined 65.8 billion lb. About 40% of this volume, or 26.5 billion lb, was sold on the merchant market; producers used the rest in derivatives.

Even more surprising was the leap in market value for petrochemicals in 1979. With a combined price pickup of 26% to an average of 17 cents a lb from 13.6 cents a lb in 1978, the five leading petrochemicals were worth 39% more in merchant sales of $4.5 billion this year. Profits probably more than doubled.

The large volume gain in petrochemicals ate up some of their 21% unused plant capacity from 1978, but only 1% or so. Although this gain was better than the expected decline in use rates, it could not account for much of petrochemicals' improved financial performance.

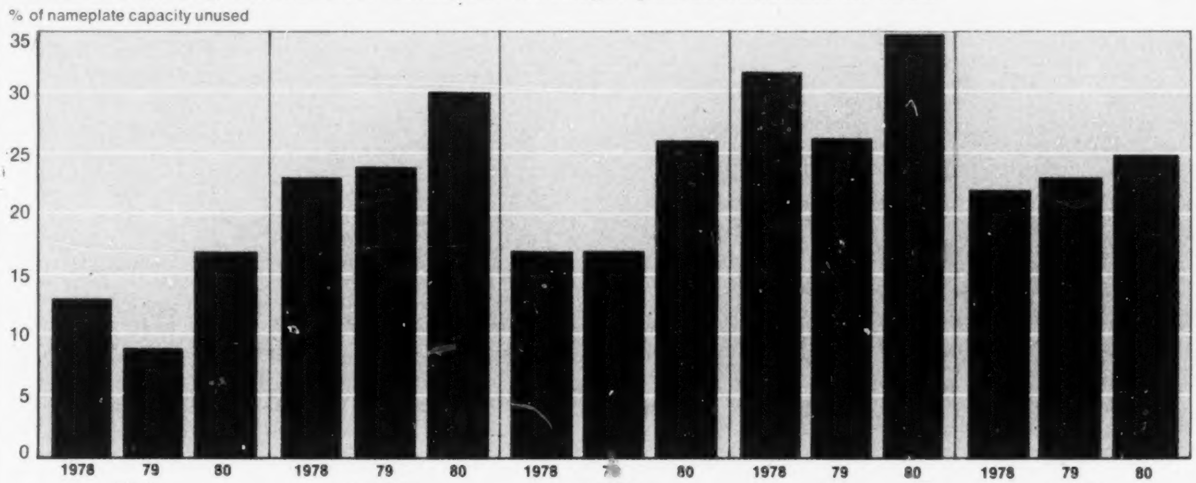
Despite the official margin of unused plant capacity, petrochemicals went into snug supply. This allowed producers to pass along increased costs to customers and rescue low profit margins besides.

The tight supply development was due to feedstock problems, which put a ceiling on production. The villain of the piece, at least to petrochemical producers, was gasoline. Gasoline shortages, especially of high-octane grades, led oil companies to divert mixed aromatic streams and propylene at oil refineries and some pyrolysis gasoline streams (aromatics) at ethylene-producing steam crackers to gasoline needs. Prices for these materials skyrocketed. Petrochemical producers substituted some natural gas liquids for these materials, but such substitution can only go so far.

One event that could solve the feedstock question would be a recession, which never arrived in 1979 for petrochemicals but which may now be close. However, there is some reason to hope that 1980 will not repeat the crushing setback of the recession in 1975. Even with its unusual financial gains, 1979 was no 1974, when petrochemical prices and market value more than doubled and plant capacity literally ran out. Without the same degree of excess, 1979 could lead to a milder correction in 1980.

Bruce Greek, C&EN Houston, and William Fallwell, C&EN New York

Unused capacity will resume climb for all major petrochemicals in 1980



Sources: Industry, C&EN estimates

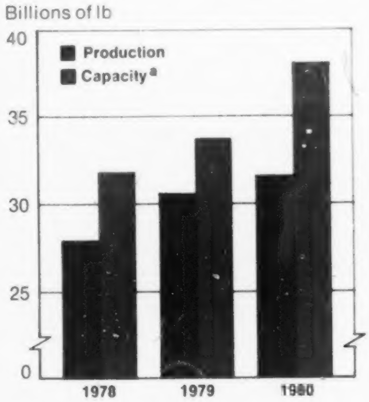
Key Chemicals

$CH_2{=}CH_2$

Ethylene

- ***Demand growth iffy***
- ***Capacity well up***
- ***Prices still rising***

PRODUCTION/CAPACITY



a As of first quarter

HOW MADE

Thermal (steam) or catalytic cracking of hydrocarbons ranging from natural-gas-derived ethane to petroleum-derived gas oil

MAJOR DERIVATIVES

Polyethylenes 45%, ethylene oxide/ glycol 2%, vinyl chloride 15%, styrene 10%

MAJOR END USES

Fabricated plastics 65%, antifreeze 10%, fibers 5%, solvents 5%

FOREIGN TRADE

Negligible

PRICES

16 to 19 cents per lb

COMMERCIAL VALUE

$4.5 billion for total production, 1979

U.S. ethylene producers are ending a good, if not excellent, year. They have the plant potential to repeat, but market and feedstock costs may not allow it if a recession deepens in the U.S. in 1980.

As yet signs are very unclear as to how much of a recession there really is in the U.S. Signs are clear enough, however, that many in the industry doubt there will be a repeat in 1980 of 1979's growth in ethylene production.

Unfortunately, a lot of new capacity is just going on stream and more is coming during 1980.

Production of ethylene during 1979 will hit a record, exceeding 30 billion lb, up about 10% from 1978.

Plant operations in 1979 were close to 90% of average nameplate capacity. This is about the practical limit. During the spring, some tightness in ethylene supply developed as some plants were closed down for maintenance.

A repeat of this near-optimum level of operation will not occur in 1980. Production optimistically will increase 1 billion lb or less, a 3% gain. But plant capacity will be up more than 4 billion lb as the year begins. Additional capacity will be coming on stream in the spring and could be operated enough during the second half of the year to add the equivalent of another 1 billion lb of capacity for the year. As a result, plant operations during 1980 probably will average a bit more than 80% for the industry.

This undesirably low level of plant use could set the stage for profitability trouble in 1980. If a U.S. recession cuts deeply into ethylene markets, which are centered on consumer plastics in uses led by packaging, ethylene producers will have a hard time passing along increased raw materials costs to customers. Plant use could be even worse than 80% in 1980 if ethylene production drops from 1979, as a minority of industry observers expect.

However, many plants are scheduled to be closed down sometime during the year for maintenance. Some of this maintenance has been deferred from 1979 because of market pressure. A major turnaround on an ethylene plant typically takes six weeks, or about 10% of the year.

Such maintenance, important to a plant that may have cost $500 million, can be deferred only so long before risk of a major accident becomes high. It's considered good business to handle these major turnarounds when demand is slack, as anticipated for the first half of 1980.

Accurate estimates of operating levels depend on good estimates of production, which have been under suspicion during 1979. Apparently some double counting has been found in production numbers, which possibly are inflated.

The problem appears to be in integrated plant complexes, where unreacted ethylene from derivative production is recycled through the purification sections of ethylene plants for cleanup and counted twice as ethylene output. Thus, 1980 production figures are expected to become more accurate as recycled ethylene is eliminated.

Besides uncertainty in demand because of recession, uncertainty in ethylene feedstocks concerns producers. During 1979, a major change in feedstocks occurred as producers moved to use more natural-gas-derived ethane and propane in their ethylene-producing steam crackers at the expense of naphtha and gas oil from oil refineries. The quantity of naphtha in particular has been reduced because of its value and demand in gasoline. Most basic hydrocarbon mixtures that fall into the naphtha category can be used in either gasoline or olefins. Similarly, gas oil can be used either in home heating oil or in olefins.

A major cost advantage continues to exist for the light hydrocarbon feedstocks, although this advantage has shrunk somewhat. As long as the light hydrocarbons are available, they will get the nod for use in steam crackers.

Even so, feedstock costs continue to pressure product prices. After a prolonged calm, ethylene prices shot up in July and October from 14 cents to the current 16- to 19-cent range. Price pressure will continue.

Prices of ethylene derivatives haven't gone up enough yet to dampen exports significantly. As U.S. sales of ethylene derivatives have weakened, exports have continued strong. Exports in 1980 could be the key to ethylene-production growth, or lack of growth, during the year.

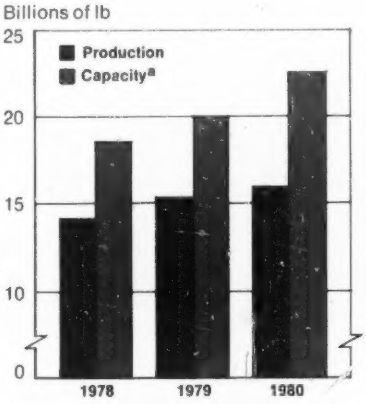
Key Chemicals

Propylene

$CH_2{=}CH{-}CH_3$

- ***Demand big question***
- ***Capacity expanding***
- ***Prices rising***

PRODUCTION/CAPACITY



a As of first quarter.

HOW MADE

Recovered from cracked gas streams of oil refineries, coproduct streams of steam-cracking ethylene plants

MAJOR DERIVATIVES

Polypropylene 25%, acrylonitrile 15%, isopropyl alcohol 10%, propylene oxide 10%

MAJOR END USES

Fabricated plastics 50%, fibers 15%

FOREIGN TRADE

Exports—negligible; imports—small, about 500 million lb

PRICES

Polymer grade—15 to 16 cents per lb, chemical grade—1 cent per lb less

COMMERCIAL VALUE

$2 billion for total production, 1979

Propylene production for use in chemicals in 1980, like ethylene, won't repeat the strong performance of 1979. Propylene, as always, will be heavily influenced by ethylene production because of its coproduct status in olefins-producing steam-cracking plants. But important differences could develop for propylene in 1980 because of changed feedstocks.

Depending on ethylene production volume and feedstocks, propylene might tighten enough to reduce the longstanding 3-cent differential in price between the two a quarter or half a cent. Even so, change also might not last.

Propylene production, though well up in 1979, is trailing the percentage gain for ethylene. The reason is a shift in feedstocks at steam crackers during the year to ethane and propane at the expense of naphtha and gas oil. This penalizes propylene output gains.

Propylene production is up 1 billion lb for 1979, or 6 to 7%, to 15.2 billion lb. This amounts to 50% of ethylene output, compared to 51% in 1978.

In 1980, industry sources expect that nearly all additional ethylene and propylene output will come from ethane and propane feedstocks. Hence, propylene again may trail ethylene output growth, and supplies of propylene could tighten unless the recession intervenes. The other major source of propylene, besides steam crackers, is refinery catalytic cracking operations, which also supply small quantities of ethylene. Here, however, the situation is complicated by competing demand for fuels.

Propylene available from refineries could be enough for chemicals if enough incentive (the right price) comes from chemical producers to recover this propylene. Chemical producers must bid away propylene that otherwise would be used in making alkylate with C_4's and C_5's for blending into gasoline. Some refinery propylene is even burned on the spot for fuel or mixed with propane fuel.

The potential availability of propylene for chemicals from refineries accounts for the large officially unused plant capacity to produce propylene.

How much of a price incentive is needed to lure this propylene to chemicals depends on an individual refiner's situation. If, for example, the refiner needs additional hydrocarbons to meet gasoline requirements, especially for high-octane grades, and has a reasonably good supply of a high-octane blending component such as toluene, he would be more likely to put more propylene alkylate into his gasoline pool and allow less to go to chemical uses.

How strongly chemical producers will have to bid for refinery propylene will depend on chemical demand. Nothing spectacular is expected to happen to demand for propylene during 1980 except for exports of polypropylene. Overall, propylene output is expected to increase 4% in 1980 to 15.8 billion lb.

Polypropylene exports during some months in early 1979 were more than double exports a year earlier. This pace appeared to slacken near midyear, but in August, the latest month for which data are available, exports picked up some 20 million lb over July for a 110% gain from August 1978.

One of the reasons suggested for the renewed rise in polypropylene exports is that more polypropylene was available. Plant production problems have hampered output of polypropylene during 1979 but now may be over, allowing greater use of plant capacity.

Higher polypropylene output will push up demand for propylene. This gives the potential of tightening propylene supply if its production is limited by lighter feedstocks in steam crackers.

The other important uses of chemical- and polymer-grade propylene likely will have modest growth during 1980. The consumer products made from these derivatives as well as from polypropylene will be influenced by economic conditions and consumer discretionary spending. Furniture sales, for example, could be hurt during a recession. This would lower demand for polypropylene fibers as well as polyurethanes made from propylene oxide.

Propylene producers maintain an optimistic view and plan to have all the product that consumers will need. At the same time, costs of making chemical- and polymer-grade propylene are going up. Propylene prices will have little chance to avoid increases even if demand falls unexpectedly more than current readings of the recession suggest.

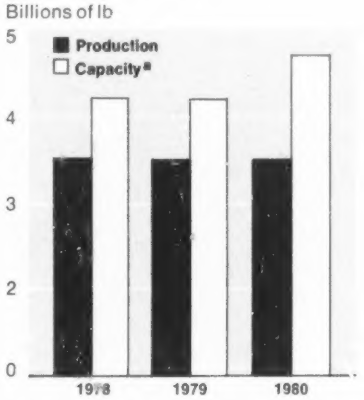
Key Chemicals

$CH_2=CH-CH=CH_2$

Butadiene

- ***Demand flat***
- ***Capacity variable***
- ***Prices rising***

PRODUCTION/CAPACITY



a As of first quarter. Combined capacity for dehydrogenation and extraction from cracked-gas streams.

HOW MADE

Recovery from coproduct streams of ethylene-producing steam crackers, dehydrogenation of butylene or butane from refineries and natural gas

MAJOR DERIVATIVES

Styrene-butadiene rubber 50%, polybutadiene rubber 20%, other rubbers 10%, hexamethylenediamine

MAJOR END USES

Tires and other rubber products 80%

FOREIGN TRADE

Exports—about 100 million lb; imports—about 450 million lb

PRICES

Contract—27 cents per lb

COMMERCIAL VALUE

$850 million for total production, 1979

Butadiene will have another flat year in 1980. For a variety of reasons, U.S. production of the only commercially important diolefin will hold at the same level of 3.5 billion lb as in 1978 and 1979.

U.S. demand, which is partially satisfied by imports, will be down slightly in 1979 and may be up slightly next year. These demand changes, however, are small, on the order of 1%. The most important reason for butadiene's stagnation is lack of "incentive" (the price bid by producers) to justify getting feedstock materials away from other uses.

Behind the lack of incentive is a fundamental, long-term market problem—no growth in the dominant end use area, tires. Rubber going into tires is the only market that really matters for butadiene. This is unfortunate, since the tire business has been a leading casualty of the energy crisis in the U.S.

After a dearth of net expansion in 1977 and 1978, plant capacity to make butadiene has risen during 1979 and will rise again during 1980. Perhaps a quarter of this capacity will not be used in 1980.

Before 1979, capacity to make butadiene declined in the U.S. Plants dehydrogenating normal butane to butadiene were permanently closed and not fully offset by new capacity from olefins-producing steam crackers. The decline in capacity has been halted because the closing of dehydrogenation plants has stopped, at least temporarily.

However, adding new capacity doesn't necessarily cause production to grow. The lack of growth in butadiene production involves some complex feedstock economics. Briefly, even though most new olefins plants are built to use naphtha or gas oil feedstocks, they are being fed significant amounts of light hydrocarbons—ethane, propane, and butane—because these materials are less expensive generally than naphtha and gas oil, which can be used in gasoline and fuel oil. The result of using the lighter hydrocarbons as feedstocks is lower production of butadiene.

Since not as much butadiene is available from olefins plants as forecast, production of butadiene from dehydrogenation plants continues. The lives of these old dehydrogenation plants could become much longer than anyone had thought, if sustained production of light hydrocarbons feedstocks from natural gas for olefins plants continues at high levels.

Certainly not helping butadiene production is the market, mostly rubber for tires. During late 1978 and early 1979, rubber and tire production ran at near capacity in anticipation of a possibly long strike by the United Rubber Workers. When the strike didn't develop, tire inventories were suddenly excessive.

On top of this, demand for tires this summer failed to reach anticipated levels. One reason was the shortage of gasoline, which, in turn, led to relatively more in-town driving in contrast to high-speed country driving. This change in driving habits increased tire life. Increased use of radial tires also increased tire life. Automobile production also declined, which further reduced demand for tires and other fabricated rubber items used in autos.

Thus, the outlook for styrene-butadiene rubber (SBR) production for 1980 ranges from a possible decline of 1% to a small growth of 1.5%. Output of other types of rubber that incorporate butadiene may not decline, but neither will it grow very much in 1980. Demand for butadiene in these polymers is small compared to SBR.

Another polymer, acrylonitrile-butadiene-styrene, ranks well behind rubbers as a use for butadiene. Demand for ABS resins is forecast optimistically to grow moderately, about 5 to 7% annually, but this kind of growth rate will do little to change demand for butadiene.

Use of butadiene in making nylon through a precursor, hexamethylene diamine, continues to grow slowly but may have a recessionary breather. Again, this use is not big enough to offset declines or no growth in production of SBR.

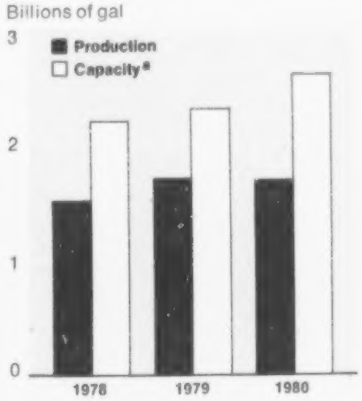
On balance, butadiene will have a lackluster year in 1980. Production will be about constant. Prices will rise as hydrocarbon costs increase. The price increases could go through a series of postings initially higher than selling prices, but with the net increase about that of crude oil. As a result, profitability will remain little better than marginal.

Key Chemicals

Benzene

- ***Demand steady***
- ***Capacity up modestly***
- ***Prices pushing up***

PRODUCTION/CAPACITY



a As of first quarter

HOW MADE

Separated from catalytic reformate from oil refineries, from pyrolysis gasoline from steam-cracking ethylene plants, and from coal tar; dealkylation of toluene

MAJOR DERIVATIVES

Ethylbenzene 50%, cumene 15%, cyclohexane 15%, aniline 5%

MAJOR END USES

Polystyrene 25%, nylons 20%, other styrenic polymers 10%

FOREIGN TRADE

Exports and imports small

PRICES

Contract—$1.50 to $1.60 per gal, spot—about $1.65 per gal

COMMERCIAL VALUE

$2.5 billion for total production, 1979

U.S. benzene production will be up substantially in 1979, 13% to 1.7 billion gal, but is expected to level off during 1980 for the usual reasons in an economic recession.

Nameplate capacity for benzene also will be up 13%, to 2.6 billion gal, by first-quarter 1980 from a year ago. Most of the new capacity will be for coproduction at olefins-producing steam crackers. Some smaller additional capacity will become available during 1980.

The growth in benzene production during 1979 could have been even larger, since more capacity to make this aromatic was certainly there. The cap on production was set by feedstock availability and demand.

The feedstock limitation traces back to the major hydrocarbon problem of 1979, Iran's cutoff of oil in the first half. But it also involves lower-cost light hydrocarbons being used in steam crackers to make ethylene replacing some naphtha and gas oil. The lighter feedstocks produce less benzene.

Production of benzene and other aromatics in oil refineries, another major source in catalytic reforming processes, is slowly failing because of changes in the kinds of crude oil available to refiners. In general, supplies of light, low-sulfur crude oil that is rich in precursors for aromatics continue to decline throughout the world. This change has nothing to do with politics or other nontechnical factors. It is the result of the more desirable crude oils being used first, as might be expected for any naturally occurring commodity.

The crude oil evolution also changes feedstocks to refineries' catalytic reformers. These feedstocks are generally in the gas oil (light fuel oil) range. They don't have so high a concentration of naphthenes and aromatics as the feedstocks expected when the reformers were designed. As a result, reformer output drops.

The obvious way to regain reformers' yields of aromatics would be to collect refineries' hydrocarbon fractions that are closer to the ideal reformer feedstocks. This would raise aromatics production but at a possible penalty to other refinery products. To date, this is not being done extensively.

The other capacity-type limitation to higher benzene production in 1979 has been capacity ceilings at derivatives plants. Some derivatives capacity simply gave out. In others, there were mechanical problems limiting operations for various periods.

Availability of other nonbenzene raw materials for these benzene derivatives was not a serious problem. For example, there was adequate ethylene for making ethylbenzene and propylene for making cumene.

The outlook for benzene volume in 1980 depends on derivatives exports. For example, exports of styrene, phenol, and cyclohexane currently account for 10 to 20% of U.S. production. Such a strong export position results from the cost advantage U.S. producers have over foreign producers because of the remaining price controls on part of U.S. crude oil.

However, this cost advantage for U.S. derivatives production is narrowing with time. The eventual result will be declines in benzene derivatives exports, possibly in 1980 for some.

U.S. markets for most benzene derivatives are expected to remain flat or be modestly higher in 1980. Sales of some derivatives will decline—for example, phenol because of the recession's impact on housing, its most important end use. Such declines will offset gains in other benzene uses.

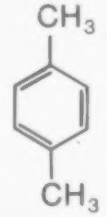
Styrene in the U.S. also could be adversely affected by the recession. The slumping tire market is an example, through its use of styrene-butadiene rubber. In polystyrene, the diversity of uses probably will moderate the effects of a recession, but polystyrene production likely will grow less in 1980 than its 5% rate in 1979.

Overall, even with export strength, phenol and cyclohexane could have small net declines in benzene demand in 1980. Cyclohexane faces a double threat in U.S. markets in 1980. Its only important outlet, nylon fiber, depends heavily on housing (carpets) and textiles. Both areas traditionally are early victims of recession. This time, both are showing some weakness.

The net outlook for benzene in 1980 is for no change in production, small use of new capacity, and efforts by producers to keep prices rising in line with crude oil prices.

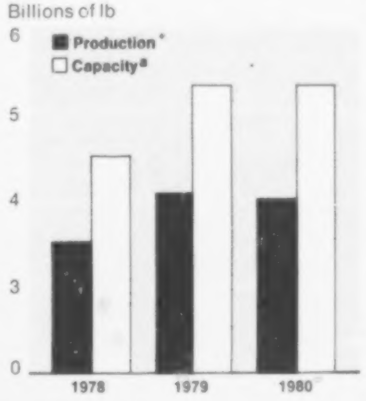
Key Chemicals

p-Xylene



- ***Demand to fall***
- ***Capacity flat***
- ***Profitability shaky***

PRODUCTION/CAPACITY



a As of first quarter

HOW MADE

Separated from mixed xylenes made in oil refineries, catalytic reformers, or in steam-cracking ethylene plants

MAJOR DERIVATIVES

Dimethyl terephthalate 55%, terephthalic acid 45%

MAJOR END USES

Polyester fibers, films, and fabricated items 100%

FOREIGN TRADE

Exports—might reach 700 million lb in 1979; imports—negligible

PRICE

Contract—26 cents per lb, spot market—negligible

COMMERCIAL VALUE

$900 million for total production, 1979

To some market analysts in the U.S. chemical industry, the outlook for *p*-xylene has become grim. True, production rose substantially through much of 1979, leading to a likely 17% annual gain to 4.1 billion lb. Plenty of plant capacity was available with a nameplate total of 5.3 billion lb all year. And prices about doubled in steps during the year.

That would be a more-than-pleasing performance for an old petrochemical had not a dark cloud come over *p*-xylene in the third quarter. Demand for its dominant derivative, polyester for fiber, fell significantly. With the current emphasis on minimizing inventory throughout the chemical product chain, producers of *p*-xylene expect a demand slump for their product in the near future.

As a result, *p*-xylene is one of the first chemicals in line for trouble from a U.S. recession in 1980. The cold-eyed view calls for a slowing in *p*-xylene demand during fourth-quarter 1979 but perhaps not to a point below demand a year ago.

However, demand would drop year-to-year in first-quarter 1980. The decline could be large, as much as 10% of production.

Output of *p*-xylene might improve in second-quarter 1980 but would still trail output in second-quarter 1979. Then a flat-to-slightly-improved third quarter is forecast and a still better fourth quarter.

The recovery in late 1980, however, would not be enough to offset the disastrous first quarter and a weak second quarter. For this reason, *p*-xylene production in 1980 likely will decline a bit, about 2 to 3%, from 1979.

Capacity for *p*-xylene will stay the same in 1980 as might be expected from the size of current unused capacity, more than 20% rising to possibly 25% next year. If annual demand growth after the recession remains relatively low, averaging 5 to 7%, capacity expansion seems unlikely for the next several years.

No important limitations to production are likely from raw material supply of mixed xylenes from oil refineries or olefins-producing steam crackers. Most of the xylenes supply comes from refineries' catalytic reformers, whose aromatics output is falling slowly long-term because of a lack of suitable feedstocks.

Tightness did develop in supplies of mixed xylenes earlier in 1979 as the gasoline shortage worsened. Anything that had good octane value was needed for gasoline. Prices of these gasoline materials went up faster than did *p*-xylene prices for a while. A quick look at economics shows that profitability of extracting *p*-xylene for chemicals was meager, so feedstock to *p*-xylene separation plants was limited.

Later in 1979, when *p*-xylene prices rose two thirds, *p*-xylene could be recovered from mixed xylenes with good profit margins. Mixed xylenes probably will continue to increase in price, even though competing toluene is a slightly better octane-boosting component for gasoline.

However, efforts to pass through additional cost increases for *p*-xylene could be difficult during first-quarter 1980 if demand slumps. The old profitability problem would then return.

Profits also could be hit from another side, the export market, which is taking more than 15% of U.S. production in 1979. Exports are forecast to decline in 1980 as cost increases continue for crude oil in the U.S. and as new capacity for *p*-xylene starts up in other parts of the world. New plants outside the U.S. could become competitive suppliers both in local markets and in the general export market.

In the U.S. market, much is being made of the fast-rising use of derivative polyester in soft-drink bottles. The growth rates in these uses are large, but the product base is still small. As a result, the impact on gross *p*-xylene demand will be hard to discern in the next year.

Farther in the future, *p*-xylene use in bottles could become major, especially if the trend continues for bottle-curbing litter laws to fail in legislatures, referendums, and the courts.

In sum, for 1980 *p*-xylene's demand problems for polyester fiber could lower production from 1979. If recovery takes hold in late 1980, only one year of lower production of *p*-xylene will occur this time, in contrast to the two-year recovery time needed after the 1974–75 recession.

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Chemical & Engineering
NEWS
December 3, 1979

U.S., Canada tackle acid rain problem Page 15

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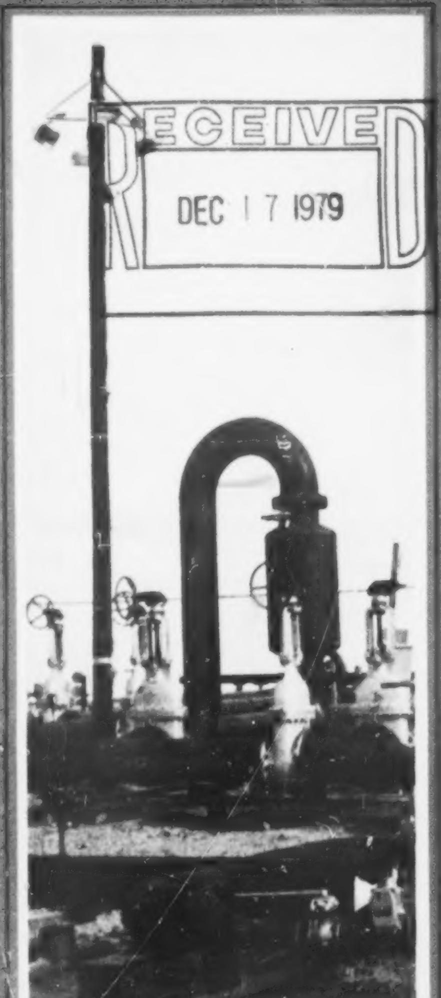

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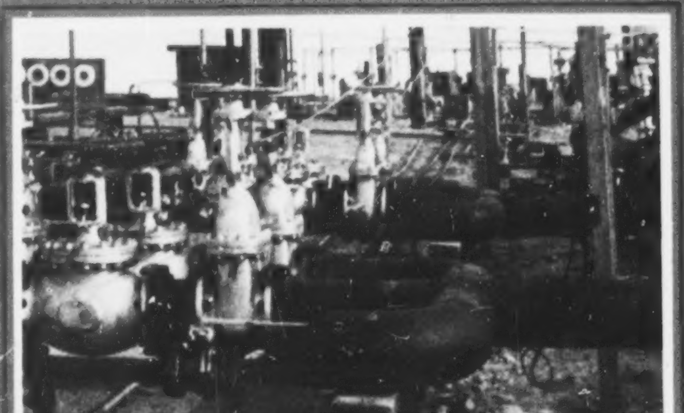
UNDERGROUND COAL GASIFICATION

Entering crucial development phase Page 19



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Chemical & Engineering NEWS

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Cover: Aboveground setup for Lawrence Livermore Laboratory's underground coal gasification at Hoe Creek, near Gillette, Wyo.

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News of the Week

- ***Oxirane Chemical's process*** *to make ethylene glycol directly from ethylene has proved a failure; after two years of low operating rate and subpar product, plant has been shut down, tightening glycol market.* **Page 6**
- ***Pennwalt predicts fourth-quarter earnings*** *of almost $14 million, up 32% over 1978's like period; chlorine and caustic soda market is on the rise.* **Page 7**
- ***U.S. acrylic fibers are being dumped*** *in Western Europe, Commission of the European Communities finds; imposes duty of up to 25% on imports in EC countries.* **Page 7**
- ***High energy prices*** *will force the consumer to conserve and fossil fuels and light-water nuclear reactors can see the U.S. through the short term.* **Page 7**
- ***Second of semiannual series of regulatory calendars*** *published by the government's Regulatory Council contains data on economic impact and cost impact of many of the proposed regulations.* **Page 8**
- ***Production-scale gas chromatograph*** *developed by French firms, in operation at SCM organic chemical plant in Jacksonville, Fla., can handle about 100 metric tons of purified product per year.* **Page 8**

Business

- ***Tax break is likely for industry*** *in 1980. Legislation permitting faster depreciation of existing assets, which would encourage a stepup in capital investment, has good change of being passed.* **Page 10**
- ***Chemical industry is getting safer*** *for workers. Incidence of injury rate was 7.2 per 100 full-time workers in 1978, down from 7.3 in 1977, 8.2 in 1976.* **Page 12**

Government

- ***Agreement to reduce air pollution*** *and its by-product, acid rain, has been signed by 33 nations in Geneva; U.S. and Canada speed up their own efforts to halt transboundary air pollution.* **Page 15**

Technology

- ***Underground coal gasification*** *is at the threshold of a crucial precommercial development phase; if experiments are successful, this gasification method could help offset energy crunch.* **Page 19**
- ***New method to clean geothermal steam*** *used for generation of electricity has been developed by EIC Corp; process removes 95% of hydrogen sulfide from single stream with recyclable copper sulfate.* **Page 29**

Books

- ***Geneticist paints stark picture*** *of a crisis linking both science and western civilization—a crisis created by scientists' betrayal of their values.* **Page 33**

ACS News

- ***CA Selects series*** *of biweekly current-awareness publications is adding 30 more titles in January.* **Page 36**

Business likely to receive tax breaks in 1980

Legislation allowing faster depreciation of existing assets probably will be passed to encourage increased capital investment

William F. Fallwell
and William J. Storck
C&EN, New York

Complaints about taxes are nothing new. The seeds of Proposition 13 go back as far as the Greeks when philosopher Plato accused a tyrant of impoverishing the citizenry by taxation. That way, citizens would be so busy supplying basic needs that they would have no time to conspire against the ruler.

Taxes today are no less political than they were in Plato's time. Tax rates are raised during inflation to slow the economy. Rates are lowered during recession to spur the economy. And in their most political use, they are lowered during election years to curry favor with voters.

In the past these changes have been made without the insistence of the voters. But recently, the voters have been quite vocal on revision of tax laws. These revisions range from cuts in rates to limits on spending. And the mood is not confined to the individual taxpayer.

Recently, the mood has spread, although for different reasons, to business. Businessmen want a cut in taxes primarily to spur capital investment, which they say has been lagging through the 1970's.

The U.S. chemical industry is well represented among proponents of investment-targeted tax breaks for 1980. The big hope, rated a good chance for success, is faster depreciation on existing assets. This increases the current set-aside from revenues for building new plants, although it also reduces the tax take from business. This drawback could weigh considerably in deficit-ridden Washington.

The chemical industry can point to its own record in the past decade for the effect of lower tax rates on investment. With an average tax rate falling from 45.6% in 1968 to 38% in 1978, largely through the investment tax credit, the chemical industry has pushed up capital expenditures as a percentage of net plant from 15.7% to 21.3% during the same 11-year period.

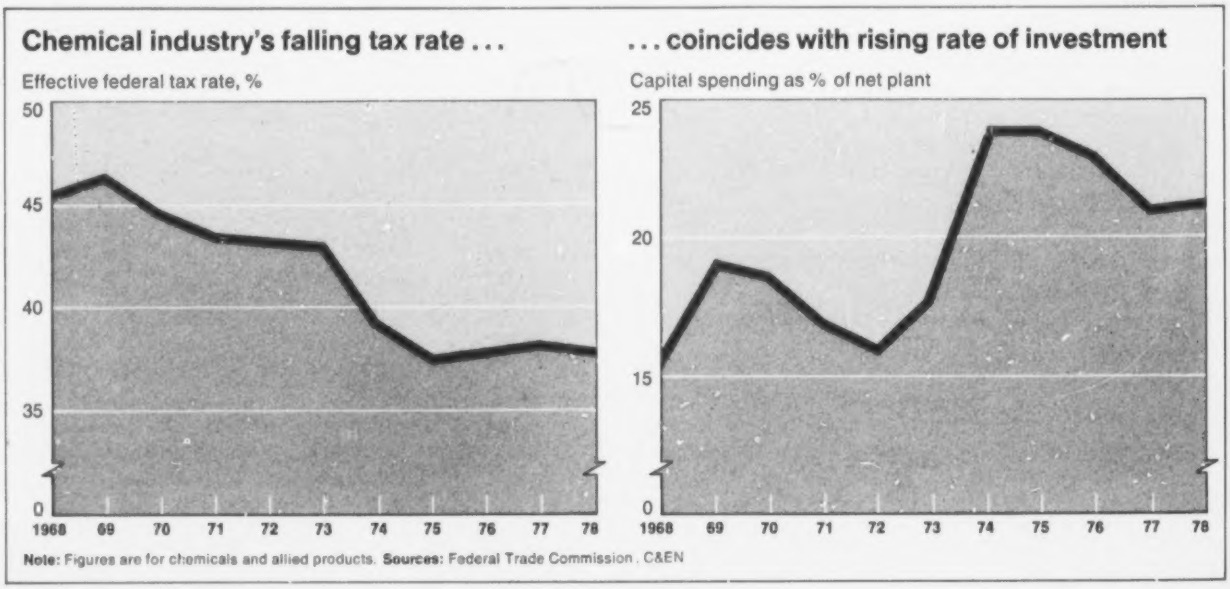
But even this relatively greater replacement rate on old plants isn't enough, chemical officials say. And many other industries on which the chemical industry depends as customers or suppliers are not investing even this fast. As a result, they point out, the U.S. has the oldest average industrial plant in the noncommunist world.

Also, U.S. consumer dollars are chronically outpacing the supply of goods and jobs. The result: inflation, the lowest savings rate among industrialized countries, and high unemployment.

J. Peter Grace, president and chief executive officer of W. R. Grace & Co., has called for complete elimination of the capital gains tax as a way to bring more investors into the economy.

And Warren M. Anderson, president of Union Carbide, told a meeting of the Drug, Chemical & Allied Trades Association in New York City earlier this month that there is an urgent need to generate capital and cash flows for new investment.

Anderson said, "Our task in the next decade will be no less than retooling and modernizing the industrial base of the U.S. Our plant and equipment is on average older and less efficient than [that of our] European and Japanese competitors, and our national fiscal policies have yet to deal with this very fundamental problem."



Chemical industry's falling tax rate . . .

. . . coincides with rising rate of investment

Note: Figures are for chemicals and allied products. **Sources:** Federal Trade Commission, C&EN

Investment tax credit already shaves the tax rate for leading U.S. chemical companies

	1978					1977				
	Federal tax rate	State, local taxes	Investment tax credit	Other tax adjustment	Effective tax rate	Federal tax rate	State, local taxes	Investment tax credit	Other tax adjustment	Effective tax rate
Air Products	48%	2.8%	−3.6%	2.8%	50.0%	48%	2.5%	−3.1%	−1.9%	45.5%
Allied Chemical	48	0.6	−5.4	11.9	55.1	48	1.9	−4.5	−2.5	42.9
American Cyanamid	48	0	−8.4	−2.0	37.6	48	0	−7.0	−2.1	38.9
Big Three Industries	48	0	−10.7	−2.0	35.3	48	0	−19.5	−1.3	27.2
Celanese	48	0	−15.7	−0.2	32.1	48	0	−9.7	2.5	40.8
Diamond Shamrock	48	0	−11.3	−6.7	30.0	48	0	−7.9	−4.1	36.0
Dow Chemical	48	1.0	−7.0	−2.3	39.7	48	1.2	−6.7	−2.6	39.9
Du Pont	48	2.0	−3.5	−5.7	40.8	48	2.0	−4.2	−2.2	43.6
Ferro	48	0	−1.2	−4.2	42.6	48	0	−1.1	−1.4	45.5
W. R. Grace	48	1.9	−3.5	0.5	46.9	48	1.5	−6.3	3.1	46.3
Hercules	48	0	−3.0	−3.0	42.0	48	0	−9.0	6.0	45.0
International Flavors	48	0	0	−3.5	44.5	48	0	0	−1.5	46.5
International Minerals	48	0	−5.6	−2.8	39.6	48	0	−8.2	−5.7	34.1
Liquid Air	48	0	−8.4	−3.4	36.2	48	0	−6.6	−6.4	35.0
Lubrizol	48	0	−0.6	−3.4	44.0	48	0	−8.9	−2.0	45.1
Monsanto	48	1.3	−4.9	3.1	47.5	48	8.6	−7.3	−1.9	47.4
Nalco Chemical	48	1.7	−1.1	−2.3	46.3	48	1.6	−1.7	−2.1	46.0
Olin	48	2.3	−16.9	−5.4	28.0	48	2.8	−12.4	−3.7	34.7
Pennwalt	48	0	0	3.6	44.4	48	0	0	−0.7	47.3
Petrolite	48	0	−1.1	−3.2	43.7	48	0	−8.3	−.8	40.9
Reichhold Chemicals	48	2.3	−4.0	−5.6	40.7	48	1.6	−9.4	−2.8	37.4
Rohm & Haas	48	0	−3.4	0.9	45.5	48	0	−9.1	−2.3	36.6
Stauffer Chemical	48	2.0	−9.0	−3.0	38.0	48	2.0	−7.0	−1.0	42.0
Union Carbide	48	0.8	−3.1	−12.9	32.8	48	0.7	−2.6	−16.0	30.0
Witco Chemical	48	0	−1.4	−2.1	44.5	48	0	−2.7	−1.9	43.4
AVERAGE	**48%**	**0.7%**	**−5.3%**	**−2.0%**	**41.1%**	**48%**	**1.1%**	**−6.0%**	**−2.2%**	**40.7%**

Source: Price Waterhouse

Anderson went on, "Capital will flow into new investment if present disincentives in our tax structure are removed. We need significant tax reforms that will encourage and reward savings and investment, and sound monetary and fiscal policies that will enable business to deploy investment more effectively. There are important moves afoot in Washington to confront these problems, and they have gained momentum from successes like the reduction in capital gains tax in 1978. Although the tax rate [on capital gains] was cut almost in half, federal capital gains receipts will increase as a result."

One of the moves that Anderson refers to, and which probably will pass next year, is the Capital Cost Recovery Act, sponsored by Rep. James R. Jones (D.-Okla.) and Rep. Barber B. Conable (R.-N.Y.). Under this legislation, depreciation is speeded up. Instead of useful-life depreciation of up to 20 or 30 years, based on complex formulas, the write-offs would be condensed to 10 years for structures, five years for machinery and equipment, and three years for light transportation vehicles. The 10-year term on structures may, if the bill is passed, be stretched to 15 or 20 years to counter some opposition.

By shortening the time in which assets are depreciated, a company could take bigger deductions and thus realize greater tax savings each year. In theory then, these tax savings would be reinvested in the company's business. Thus, the savings would stimulate capital investment and create new jobs.

R. Heath Larry, president of the National Association of Manufacturers, told a Conference Board meeting on taxation late last month, "This fundamental change in depreciation policy is a very necessary step if the existing tax structure is to be constructively reformed to remove tax obstacles to capital formation. It is a broad-based change. It would substantially reduce the bias against investment. It would not be a targeted approach to specific taxpayers or specific economic activities."

Carbide's Anderson told the DCAT meeting: "The Jones-Conable bill . . . would streamline depreciation to enable businesses small and large to recover their capital investments more quickly. It is a measure that should be acceptable to the public, because businesses can take advantage of it only for new investments—and that means jobs and growth."

However, in spite of assurances from many that the measure would get public support, or at least not receive general public condemnation, many tax experts say that it will not be passed as a separate measure. If the Jones-Conable legislation is passed, they say, it will be part of a broader tax bill that will include a general tax cut of about $20 billion to make the business tax reforms more palatable.

One of the things that may make the bill more acceptable is the effect it is expected to have on employment. Rep. Jones, one of the two originators of the proposed legislation, told the Conference Board tax meeting that Data Resources, an economics consulting company, has predicted that, besides raising investment and causing a turnaround in productivity, the bill will provide about 1.2 million jobs over the next five years if it is enacted. □

Learning chemistry from chemistry sets Page 40

Chemical & Engineering NEWS

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Chemical capital spending

Restrained in 1980 Page 14

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Chemical & Engineering NEWS

Cover: Union Carbide's newly expanded liquid hydrogen plant at Ashtabula, Ohio

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News of the Week

- ***Industry will be able to meet clean-air goals*** *in a cost-effective, more flexible manner under EPA's bubble concept, the regulatory agency claims.* ***Page 6***
- ***Mary L. Good*** *elected chairman of the ACS Board of Directors for 1980; committee chairmen appointed.* ***Page 6***
- ***Plastics' good showing in 1979*** *is beginning a fourth-quarter slide, but sales are expected to be 9.4% higher than in 1978 and export market will remain strong.* ***Page 7***
- ***An economic downturn*** *in first-half 1980 will be reversed by year's end, forecast Conference Board and National Association of Purchasing Management.* ***Page 7***
- ***Du Pont will sell 80% of its dyes business*** *to four different companies—Mobay Chemical, Morton Chemical, Ciba-Geigy, and Crompton & Knowles.* ***Page 8***
- ***The biennial Chem Show,*** *held this year in New York City's Coliseum, will become an annual event, alternating between New York and Chicago.* ***Page 8***

Business

- ***U.S. chemical firms' worldwide capital spending*** *will rise 13% in 1980, after 19% gain in 1979, but inflation will erode most of budgeted increase.* ***Page 14***
- ***Hydrogen peroxide capacity*** *will be boosted substantially by new Interox America plant on stream, FMC plant scheduled to start up next year.* ***Page 16***

Government

- ***Complications of setting air quality standards*** *pointed up at subcommittee hearings involving EPA, lead smelter, and citizens of Idaho community who claim children are harmed by high lead levels.* ***Page 22***
- ***Bills to change patent law and policy,*** *including patent protection for work done under government sponsorship and reduction of litigation on patent challenges, triggered by concern over innovation.* ***Page 26***

Science

- ***Electrides****—compounds of alkaline metal elements and electrons—behave in unusual manners; inability to crystallize them to determine their structure frustrates researchers in metallic chemistry.* ***Page 32***

Education

- ***Producers of chemistry sets****—frequently the child's introduction to the fascination of the world of chemical science—face a declining market as population of nine- to 12-year-olds diminishes.* ***Page 40***

Chemical capital spending up a notch in 1980

After 19% upswing in 1979, worldwide capital spending by U.S. chemical firms will rise 13% in 1980; inflation will eat up most of gain

William F. Fallwell
and William J. Storck
C&EN, New York

Despite a handsome increase in the U.S. basic chemical industry's available funds for new investment in 1979, actual outlays for capital projects (new plant and equipment) this year and next will be relatively modest.

Gains in capital spending, the largest use of company revenue after running costs and taxes, will lag behind the increase in cash flow (net income plus depreciation). Spending will barely keep up percentagewise with the gain in company sales this year and will do little better in 1980.

This restraint is in sharp contrast to the industry's exuberant reaction to swollen cash flows at the corresponding peak of the previous business expansion in 1974. That year, chemical capital spending shot up 60%, followed by a 15% gain in 1975. However, companies remember, the result was a period of retribution as the chemical industry suffered the flat earnings brought by its overbuilt capacity.

The selectivity in chemical investment this time shows up in C&EN's annual survey of spending plans of the 17 largest U.S. basic chemical companies. Their combined actual spending in 1979 is coming out to about $6.5 billion, up 19% from $5.5 billion in 1978. For 1980, plans call for a combined 13% increase to $7.3 billion.

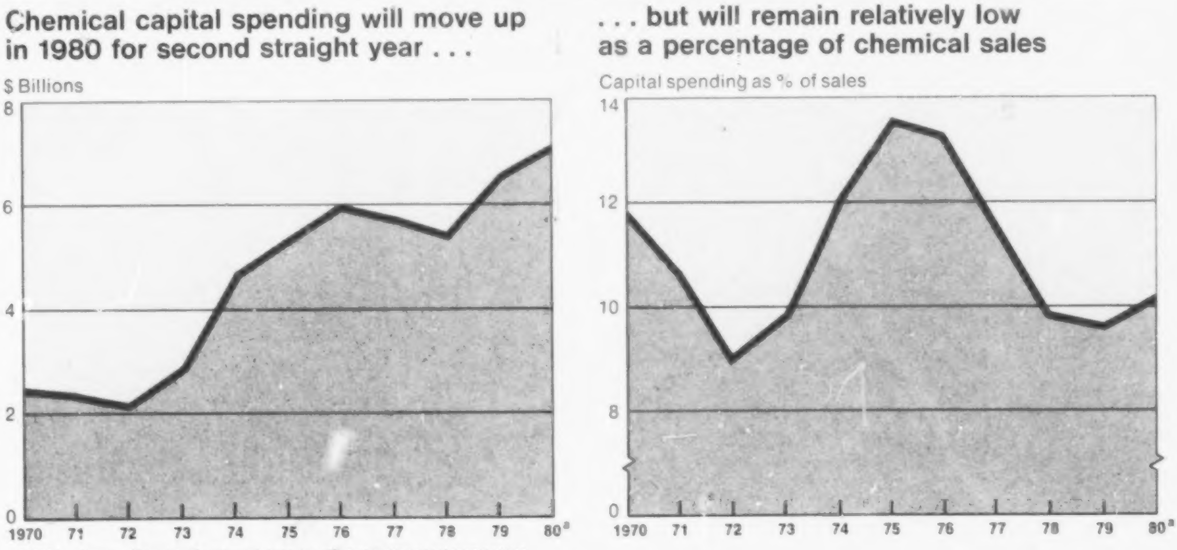
Inflation is an important corrective to all these figures. Its buildup this year undoubtedly accounts for much of the near doubling in the spending gain for 1979 from the early estimate of 11% over 1978 (C&EN, Dec. 11, 1978, page 10). And inflation will eat away practically all of the chemical industry's anticipated increase in project budgets for 1980.

Even without an inflation factor, capital spending in 1979 remains about the same as in 1978 as a percentage of industry sales. Hovering at about 10%, this level is etching out a typical trough in the industry's capital spending cycle. The previous nadir occurred in 1972, also between 9 and 10%.

In 1980, the planned spending rise could beat the increase in sales if a recession strikes the industry. But the margin won't be much, and spending could be pared in a stiff economic downturn.

The spending picture in 1980 will not get much help from non-U.S. projects. Although foreign economies are expected to stay healthier than the U.S.'s., chemical investment now is tilted strongly toward the U.S. This is true for both U.S. and non-U.S. chemical companies' worldwide investments (C&EN, Oct. 15, page 7). An initial Commerce Department survey shows a decline in U.S. chemical foreign affiliates' spending in 1980. In C&EN's survey, most companies' non-U.S. spending segment is staying the same or falling as a percentage of the total in 1980.

The reason for the investment trend toward the U.S. is the same as the boom in U.S. exports. Chemical manufacturing costs in the U.S. enjoy a distinct advantage over costs in other countries. In addition, the chemical industry in the U.S. is not as overbuilt as in Western Europe and Japan, and political and labor relations are more attractive to businessmen.


Chemical capital spending will move up in 1980 for second straight year . . .

. . . but will remain relatively low as a percentage of chemical sales

a C&EN estimate **Source:** Combined data for 17 major chemical companies

Most chemical companies plan more spending gains in 1980, but a few hold the line

$ Millions	1980 Worldwide	1980 U.S.	1979 Worldwide	1979 U.S.	Worldwide 1979 Planned[a]	Worldwide 1978	Worldwide 1977	Worldwide 1976	Worldwide 1975	Change from previous year 1980	Change from previous year 1979
Air Products	$310	$235	$246	$199	$230	$200	$143	$162	$151	26%	23%
Akzona	60	60	57	57	60	42	35	38	51	5	36
Allied Chemical	400	na	400	na	475	502	465	352	314	0	−20
American Cyanamid	na	na	225[b]	185[b]	200	251	235	232	204	na	−10
Celanese	260	224	245	211	245	248	243	223	208	6	−1
Diamond Shamrock	315[b]	285[b]	295[b]	250[b]	215	287	365	310	170	15	−4
Dow Chemical	1200	780	1200	720	1100	1075	1163	1186	922	0	12
Du Pont	1000	880	900	790	1000	714	704	876	1036	11	26
Ethyl Corp.	115	86	105	79	100	96	89	88	69	10	9
W. R. Grace	500	416	450	400	361	275	270	226	306	11	64
Hercules	220	176	175	147	133	116	127	150	151	26	51
Monsanto	680	544	525	420	575	480	607	647	528	30	9
Olin	na	na	160	150[b]	175	163	208	166	99	na	−2
Pennwalt	65	55	68	50	68	62	46	40	32	−4	10
Rohm & Haas	85	65	65	45	80	66	78	110	106	31	−2
Stauffer Chemical	na	na	210	200[b]	188	201	193	199	199	na	4
Union Carbide	1000	700	850	595	725	688	805	965	862	18	17
TOTAL FOR 13 FIRMS[c]	**$5810**	**$4508**	**$5161**	**$3963**	**$4892**	**$4349**	**$4678**	**$5021**	**$4592**		
ANNUAL CHANGE	**13%**	**14%**	**19%**	**18%**	**12%**	**−7%**	**−7%**	**9%**	**13%**		

a Earliest estimate. b C&EN estimate. c Includes only those companies with figures for all seven years. na = not available.

All the more interesting, then, is that capital spending within the U.S. is so cautious. Certainly, the money is available. Figures from the Conference Board, a New York City business research group, show the extent of the chemical industry's financial potential. Quarterly surveys show that the industry's new capital appropriations (money earmarked for projects but not yet spent) hit a record $3.25 billion in the third quarter of 1979. This figure is up 44% from third-quarter 1978. Even corrected for inflation, the rise is 32% to $1.91 billion in constant 1972 dollars. This figure breaks the old constant-dollar record of $1.81 billion set in second-quarter 1974.

Not much of this reserve may have to be spent in any case to achieve a substantial increase in new plant capacity. Dow Chemical comments that one of the major trends of the 1970's in spending breakdowns for various purposes may reverse from now on. Dow considers its extensive campaign to refit existing plants for higher cost efficiency and environmental standards largely completed. These two drives took a great deal of the company's capital spending in recent years—for example, 25% for increased cost efficiency and 15% for safety, health, and pollution control in 1978.

In fact, only 39% of Dow's 1978 capital spending went for plant capacity leading to new sales. This percentage will rise from now on, the company says.

West German spending in U.S. will rise little in 1980

Capital spending in the U.S. by the three largest West German chemical companies will increase very little in 1980 after big jumps in 1979.

Projected spending by the three top West German subsidiaries in the U.S.—American Hoechst, BASF Wyandotte, and Mobay—probably will be up no more than about 4.5% in 1980 over 1979. This trails considerably the average increase projected by U.S. chemical companies of about 10%.

The increase also is less than the 36% increase of the three subsidiaries in 1979 over 1978, or the 20% increase in 1979 by leading U.S. chemical firms.

Individually, U.S. capital spending at American Hoechst will be about $165 million, up about 3% from 1979 spending. Hoechst has budgeted about $171 million for all of North America. Mobay probably will spend about $153 million in 1980, an increase of just 2% over 1979 spending. Spending of BASF Wyandotte will be up 11% to $100 million, the largest gain among the West German-owned companies. BASF Wyandotte had kept spending constant in recent years.

The combined increase in spending is much lower than it has been in the past few years. Between 1976 and 1979, capital spending for the three subsidiaries increased at an average annual rate of 29%. This was led by American Hoechst with an average annual gain of 62%. Most of this spending was for Hoechst's big styrene and high-density polyethylene complex at Bayport, Tex. This investment is ending this year. Mobay has been right on the average from 1976 through 1979 with a 29% average annual growth rate for those years. BASF, however, has slowed the combined rates, growing at an annual rate of 6.3%.

The relatively low increase by the West German-owned firms probably means that there will be a reduction in their U.S. actual construction volume next year, as inflation wipes out some of the gain in the dollars that they have allocated.

U.S. subsidiary (parent)	Capital spending in U.S. ($ millions) 1980[a]	1979	1978	1977	1976	Change 1979–80	Average annual change 1976–79
American Hoechst (Hoechst)	$165	$160	$100	$65	$38	3%	62%
BASF Wyandotte (BASF)	100	90	75	75	75	11	6
Mobay and other subsidiaries (Bayer)	153	150	119	72	70	2	29

a C&EN estimates

But Dow, like the rest of the chemical industry, is still quite moderate in letting out new project funds. The industry's fixed asset structure is entering the 1980's in trim shape, which companies hope will lead to a faster pickup in profits than in the mid-1970's. □

Hydrogen peroxide gets spate of new capacity

Although U.S. chemical companies have been selective in their investments generally, they have been notably liberal toward hydrogen peroxide, a powerful oxidizing agent with major new markets and possibly more to come. The only question now is: Can the business digest the flood of new plant capacity from major facilities of Interox and FMC?

Last week, Interox America dedicated its new hydrogen peroxide plant at Deer Park, Tex., outside Houston, to become the third major U.S. producer along with FMC and Du Pont. Interox's 88 million lb-per-year plant has been running since late November.

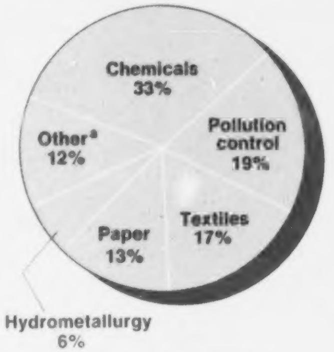
In addition, Interox, a joint venture of Laporte Industries of the U.K. and Solvay & Cie. of Belgium, will make sodium percarbonate at the plant site in a 35 million lb-a-year unit. Hydrogen peroxide to make this sodium percarbonate, a derivative of soda ash, will take about 10% of the capacity of the hydrogen peroxide plant. This leaves just under 80 million lb a year, a lot, for the merchant market.

Until the Interox plant came on stream, U.S. production of hydrogen peroxide had been less than demand of about 240 million lb, 10 to 15% in 1979, or about 30 million lb. Some of the imported material has been supplied by Interox Group plants making various peroxygen compounds. The group operates 49 plants at 22 sites worldwide, with a combined capacity of 1.5 billion lb a year of peroxygens. This capacity includes more than 530 million lb of 100% hydrogen peroxide per year.

Before Interox's Deer Park plant came on stream, U.S. nameplate capacity for hydrogen peroxide had totaled about 270 million lb a year. Du Pont and FMC accounted for about three fourths of the total.

In early 1980, another big hydrogen peroxide plant will be coming on stream. FMC is scheduled to complete a plant in the Bayport, Tex., industrial area with a design capacity of 60 million lb a year of 100% product. Hence, FMC will have the largest hydrogen peroxide capacity.

Industrial uses dominate hydrogen peroxide market



Total 1979 U.S. use[b] = 240 million lb

[a] Includes personal care products, food processing, and furniture. [b] As 100% hydrogen peroxide.
Source: Interox America

One smaller capacity change will cut the industrywide total a bit. At the end of 1979, Shell Chemical expects to halt its production, taking away about 35 million lb of available capacity. A large share of Shell's product went to captive uses such as making synthetic glycerine. As a result, the loss to the merchant market for hydrogen peroxide will be small.

On balance, about 115 million lb per year of additional capacity for hydrogen peroxide will be available in the U.S. during most of 1980. The total available capacity then will be close to 385 million lb and capacity use about 65%.

Although this total looks large, it is not quite so formidable as it looks. In the past, peroxide plants have operated at considerably less than nameplate capacity.

In 1979, for example, U.S. consumption is estimated to be 240 million lb of hydrogen peroxide. If imports account for 30 million lb, then U.S. production (excluding production at the new Interox plant) will supply about 210 million lb. Operating rates for U.S. producers would average about 78% of nameplate capacity.

In 1980, U.S. use of peroxide could grow more than the (10-year) average of 5% annually. Even in a recession, growth could exceed 5%, since peroxide's big growth markets may not feel the recession very much.

Over the next five years, compounded annual growth could average 9% annually, says David G. Birney, Interox's vice president for

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Chemical & Engineering NEWS
December 17, 1979

Pigment outlook darkens for 1980
A Key Chemicals Review Page 9

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Chemical Industry in China Page 21

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Cover: Bronze lion, symbol of Chinese emperors' might, guards a gate in Beijing (Peking) at Imperial Palace, once "Forbidden City," but now a public museum. Photo by C&EN's Richard J Seltzer

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- ***Union Carbide is streamlining*** *its plastics and chemicals division to cope with changing economic conditions.* **Page 5**
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Special Report

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Pigments head for lackluster 1980

Carbon black and titanium dioxide had a good year or two in the late 1970's, but low capacity use and recession loom in 1980

As with most other groups of leading U.S. commercial chemicals, healthy business finally caught up with top pigments in the economic expansion from 1975 through 1979. After a shaky start in 1975 and 1976, pigments moved up to various peaks for particular products in 1978 and 1979. From here on, however, producers face declining profitability brought about by increased plant capacity on one hand and declining market growth on the other.

The two pigments detailed on the following pages in C&EN's Key Chemical series are carbon black and titanium dioxide, together worth $1.4 billion in 1979. Besides holding the unchallenged leads as the top black and the top white pigments, carbon black and titanium dioxide impart valuable additional properties to end products, notably strength by carbon black and resistance to surface oxidation by titanium dioxide. Among all commercial U.S. chemicals, carbon black was 32nd in production volume in 1978, and titanium dioxide 49th.

The two pigments have shown different cycles in their business during the 1970's but have shared a common problem—lack of good demand growth. Both were hit hard after a decade production peak in 1973 and 1974, and neither has since recovered this height. Even with rising prices, the two chemicals' dollar-value growth in the 1970's pales beside the value growth in other chemical categories, such as petrochemicals and plastics.

More than most chemicals, carbon black and titanium dioxide have had to contend with customer resistance of different sorts since the 1974–75 recession. Titanium dioxide, a relatively high-priced basic chemical, ran into a cost-cutting move by paint makers to lower its proportion in paint formulations. Although this trend now may be reversed because of a consumer backlash, it hurt titanium dioxide growth.

Carbon black, perhaps the best chemical proxy for the automobile industry, caught the full brunt of the energy cost pinch from late 1973 to the present. Americans have reacted to the soaring price of gasoline in several ways that reduce the demand for new tires, the main outlet for carbon black.

Struggling with these basic handicaps in demand growth, carbon black and titanium dioxide rose slowly into reasonably good business. Tied heavily to consumer durables, carbon black reached a healthier state first in 1977 and held it through 1978. But then, along with everything else connected with automobiles, carbon black's fortunes pitched sharply downward in 1979. As in 1974, autos felt the economic slowdown well before other industries and dragged carbon black down. No relief is in sight until possibly late in 1980.

Titanium dioxide's various problems delayed recovery after the 1974–75 recession until 1978 and 1979. A bulge in excess plant capacity was brought down by closings due to pollution problems. But demand growth still could not catch up, ironically, in part, because of positive improvement in product properties enabling savings by users.

The irony was compounded by the Federal Trade Commission, which sought to break up Du Pont's leading position in titanium dioxide essentially because the company developed better technology, the ilmenite chloride process, and refused to license it. The initial decision on the case by an FTC administrative law judge sharply repudiated the FTC case (C&EN, Sept. 24, page 6), which is now on appeal to the commission. Last week Du Pont dedicated a large new plant using the ilmenite chloride process at DeLisle, Miss.

Du Pont's new plant, for all its advantages, may dampen short-term prospects for titanium dioxide. The plant has come on stream at the beginning of a likely business slowdown when existing capacity was already adequate to fill demand.

Titanium dioxide producers once again may find growth years for their high-value, high-property, high-technology product. In the late 1970's, however, these characteristics seemed to curb as much as promote it.

Carbon black producers also have a superior product for its uses and, unlike titanium dioxide producers, are protected from challengers by a low price. But carbon black must wait out a basic efficiency drive in its main market, which will hold back greater volume in tires for some time.

Unfortunately for both products, the growth lag in view for their big uses cannot be compensated for by growth in newer uses. These markets, particularly plastic colorants, are still too small to affect the whole.

Bruce Greek, C&EN Houston;
William Storck and William Fallwell, C&EN New York

After healthy pickup in late 1970's, leading pigments' capacity use is heading down

	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970
CARBON BLACK (billions of lb)											
Production	3.20	3.25	3.30	3.48	3.02	2.76	3.35	3.49	3.16	3.03	2.93
Capacity	4.28	4.01	3.65	4.10	4.07	4.25	4.22	4.17	3.98	3.75	3.66
Capacity use, %	75%	81%	86%	85%	74%	65%	79%	84%	80%	81%	80%
TITANIUM DIOXIDE (thousands of tons)											
Production	765	750	720	678	713	603	787	785	693	678	655
Capacity	1035	885	885	990	980	944	871	821	816	840	778
Capacity use, %	74%	85%	81%	68%	72%	64%	90%	96%	85%	81%	84%

Note: Capacity is nameplate total as of first quarter each year. **Sources:** Department of Commerce, industry, C&EN estimates

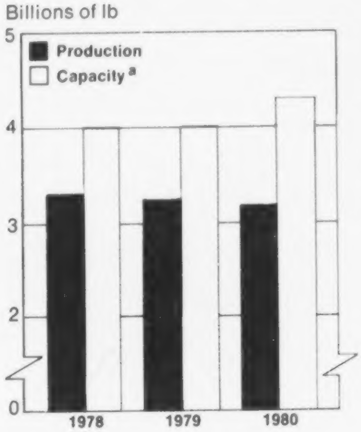
Key Chemicals

C

Carbon black

- ***Demand dropping***
- ***Prices soft***
- ***Outlook poor***

PRODUCTION/CAPACITY



a As of first quarter.

HOW MADE

Partial oxidation of residual hydrocarbons from oil refining and olefins production

MAJOR END USES

Tires 67%, other rubber products 25%, plastics, inks, paints, and other 8%

FOREIGN TRADE

1978 exports—116 million lb or 3.5% of production, 1978 imports—36 million lb or 1.1% of production

PRICES

Rubber grades 19.2 to 22.25 cents per lb in bulk lots, specialty pigment grades higher

COMMERCIAL VALUE

More than $600 million for total production, 1979

If black is considered figuratively as the color of gloom, carbon black is aptly named. U.S. producers of the pigment during the past year have been plagued by all sorts of trouble—increased costs, excess capacity, poor markets, soft prices, and high inventories, to name the most prominent.

Carbon black's 1979 problems actually began in the fourth quarter of 1978. It was then that tire companies, carbon black's biggest customers, began building inventories in anticipation of a strike. This buildup and the consequent sales bulge for carbon black continued into the first quarter. When the rubber workers' strike did not materialize, tire makers were left with huge inventories and little need for more carbon black when they cut their production.

The problem has been compounded further by the dramatic slowdown in new car sales. Thus, when car makers do not buy tires, tire makers cut down their purchases of carbon black.

Carbon black producers this year have found themselves in a classic cost-price squeeze, which is cutting profitability tremendously. Raw material costs for producers have jumped more than 60% since the start of 1979. At the same time, list prices of carbon black rose only 26 to 28%, and there has been discounting. Producers put through an increase in October, but at the same time had to increase the discounts to their customers. Producers will not say how large the discounts are, but they say that they are substantial.

Producers see no improvement in pricing in the near future. With massive inventories hanging over the market, producers are hard put to make any price increase stick. Thus pricing, at least through the first half of 1980 and possibly longer, is more than likely to be quite soft.

Adding to carbon black's problems is a lack of growth in its major markets, both in 1980 and probably longer. The tire market, which takes more than two thirds of carbon black production, has zero growth, according to carbon black producers. The depressed auto market is one reason. Another is that rubber companies are developing longer-lasting tires. Then there's the move to smaller cars and consequently smaller tires. Still another factor is the use of emergency, lightweight spare tires instead of regular tires as spares for weight savings in new cars.

Similarly, the market for carbon black in other rubber uses such as conveyor belts and industrial applications is growing very little—perhaps no more than 2% per year, and next year such growth probably will be flat.

The only market for carbon black that is growing is its use in plastics, both as a colorant and a strengthener. Producers say that this area will increase about 6% next year; however, as an end market, plastics take very little carbon black, probably no more than 2% of carbon black production.

Carbon black's remaining markets, which are small and mostly mature, are showing little if any growth. Its use in printing ink, the biggest end use after elastomers, takes only 2.5% of production and is growing at no more than 2% per year. As a colorant for paint, carbon black's growth is very slow, reflecting lack of growth in the paint industry. Paint takes about 0.5% of production.

Even the outlook for exports, which take about 3.5% of U.S. production, is bleak. More than one third of carbon black exports go to Taiwan, South Korea, and other Asian markets. However, within the next year or so, some of these countries will bring on stream carbon black plants of their own. For instance, Thai Carbon Black Co. is building a 35 million lb-per-year plant scheduled to come on stream soon. And Korea Steel Chemical Co. is building a 66 million lb-per-year plant slated to start up in late 1980.

Capacity in the U.S. is more than ample to handle any carbon black needs for the next few years. With the construction of additional plants this year, capacity has increased 7.5% from 1978 to about 4.3 billion lb. There is some talk among producers of closing older plants, but producers also say that any capacity that is shut down will be made up with expansions elsewhere. If this is true, capacity will remain stable and thus poorly used in the near future.

All in all, carbon black makers are so pessimistic that they are not even using the old rallying cry, "Wait until next year." They are more often saying, "Wait until 1981 or 1982."

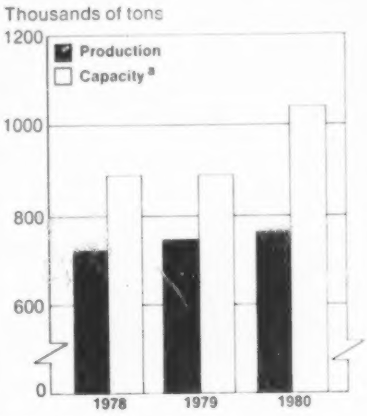
Key Chemicals

TiO$_2$

Titanium dioxide

- ***Demand up modestly***
- ***Capacity jumping***
- ***Prices still up***

PRODUCTION/CAPACITY



[a] As of first quarter.

HOW MADE

Recovered from natural and synthetic ores, using chlorine or sulfuric acid

MAJOR END USES

Surface coatings 50%, paper coatings and fillers 25%, plastics and rubber fillers 15%, ceramics 5%

FOREIGN TRADE

Exports—less than 40,000 tons, imports—about 115,000 tons

PRICES

Rutile grades 59 cents per lb, bulk contract; anatase grades 53 cents per lb, bulk contract; no significant spot market

COMMERCIAL VALUE

$800 million for total production, 1979

Titanium dioxide producers in the U.S. are gearing for a so-so production year in 1980. Sales of the dominant white pigment in 1980 probably will about equal sales in 1979.

Production could be up a bit because of inventory building and a possible small drop in imports. However, the output gain probably will not be more than 3%, or about 25,000 tons. Total 1980 production more likely would be about 765,000 tons, following an output of 750,000 tons in 1979.

This outlook takes into account the effects of a U.S. recession on consumer products containing titanium dioxide. Much titanium dioxide goes into consumer nondurables such as paper and plastics, which ride up and down with the business cycle. The pigment also has large uses in autos and housing, durables which usually magnify swings in the business cycle.

Currently, inventories of titanium dioxide are at a low point in recent history. Low stocks could lead to some supply problems during the first quarter of 1980. However, any snag could be remedied quickly because U.S. plant capacity substantially exceeds even optimistic forecasts for immediate demand.

Estimates of domestic U.S. production of titanium dioxide in 1980 range from 760,000 to 775,000 tons. The high side is just 3% over the current estimate for 1979 production of about 750,000 tons. Production in 1979 is up modestly, about 4%, from 1978 production of 720,000 tons.

Producing enough titanium dioxide to meet demand in 1980 isn't likely to be a problem except in the fairly remote event that ore supplies get much tighter than they are now. U.S. titanium dioxide capacity as 1980 begins will exceed 1 million tons with the startup of Du Pont's new plant near DeLisle, Miss. This plant was dedicated last week after an extended history of planning and construction that included a considerable delay in the mid-1970's.

On paper, because of the industry-wide capacity increase of 150,000 tons from Du Pont's plant, overall capacity use in 1980 could sink below 75% of the nameplate total from 85% in 1979. But Du Pont's new plant isn't expected to run at capacity for some time.

In addition, other titanium dioxide plants have had a record of production difficulties, many of which became severe as companies struggled to meet environmental regulations. The result is little concern in the industry about what might seem to be large overcapacity.

Similarly, the capacity situation would seem to affect both foreign trade and pricing. Theoretically, excess capacity would drive down imports, increase exports, and put downward pressure on prices. However, none of these possible impacts likely would be large.

Imports, which are substantial, could actually decline slowly during 1980, as in 1979, for various economic reasons, among which is the lower value of the dollar. Exports might increase slightly but more under the influence of world demand than of U.S. capacity.

Prices could be under pressure in 1980, but they probably will still rise because of rising energy costs. Although this cost justification is viewed as strong, no price increase seems due Jan. 1, inasmuch as the customary advance notices apparently have not gone out to contract customers.

Price increases during 1980 likely will have a negligible effect on titanium dioxide use. In a consumer product, titanium dioxide's share of the total cost is tiny.

A pertinent example is paint, titanium dioxide's largest market. For some years, paint makers reduced the amount of titanium dioxide in their formulations as one way to hold down costs. For a while, paint performance held up because of counterbalancing improvements in titanium dioxide properties. More recently, however, paint performance has declined, and dissatisfied consumers have tried switching to substitutes such as siding. As a result, paint sales at best have held level.

Faced with this reaction, paint makers are turning to selling better-quality formulations at higher prices and better profits. The effect on titanium dioxide appears to be increased use. Use of titanium dioxide in paints may increase 1 to 2% during 1980, even though housing starts will be relatively low. This increase could offset decreases in titanium dioxide sales in other much smaller uses. And total sales may hold even for the year.

Bad image a problem for chemical industry

There is an intuitive feeling that the chemical industry is entering a new era. Technical competence is not in question nor is industrial productivity. Rather, in addition to the universal problem of energy, the chemical industry's problems in the new era are more in the nature of rebuilding public confidence and in reversing misperceptions of an industry that hasn't done much to defend its past good performance.

The most demanding issues in the near future are health, worker safety, and environmental protection. These were explored from several points of view during a workshop at the American Institute of Chemical Engineers' 72nd Annual Meeting, held in San Francisco.

The closest thing to a composite public view of the chemical industry was provided by James B. Lindheim, vice president of the firm of Yankelovich, Skelly & White. A decade of public opinion polls by Lindheim's firm indicates that much of the troubles of the chemical industry also are being experienced throughout society.

In the 1970's, Lindheim says, there was nothing less than a massive social transformation of American society. He believes that most important in that transformation was the diminution, and maybe even the elimination, of the Christian ethic as a basic motivation. It has been replaced, according to the polls, with a new ethic of "self."

An individual was formerly valued for what he contributed to society through good works, family cohesion, national service, and the like. Today, Lindheim says, it appears that service to self far overshadows everything else and the criterion for success is "finding one's self." The new ethic of self pervades all age groups and all parts of the country.

Another important social trend in the 1970's that contributed to a new era of challenge for the chemical industry is called by Lindheim the "philosophy of entitlement." The basic idea is that "I am entitled to something" from the national institutions, and this includes trouble-free products from the chemical industry.

At the same time, the polls suggest that there is no desire for a welfare state—a seeming contradiction. Lindheim explains that the philosophy of entitlement is concerned more with providing a safety net than with letting someone or something else run one's life. To Lindheim this suggests social parentalism rather than paternalism. In looking ahead to the 1980's, Lindheim sees an acceleration of these trends.

Fleming: public self-praise needed

In refining his viewpoint to the specific realm of the chemical industry, Lindheim notes that the chemical industry has experienced all the problems of other industries, with two exceptions. The decline in confidence that hit all industry in the seventies didn't hit the chemical industry until about 1976. The only other one that experienced this delayed effect was the insurance industry. Also, when it did appear, public concern with the chemical industry was sharply focused on health, environmental protection, and worker safety.

Beginning roughly in 1976, the polls showed a sharp rise in the number of people who believed, rightly or wrongly, that the chemical industry was not doing a very good job in these three areas. Today more than half the people polled consider the chemical industry the worst in matters of health and environmental damage. The chemical industry is tied with the mining industry as the least safe industry to work in.

According to Lindheim, the reasons for the public perceptions of the chemical industry also have appeared in the polls. In the case of health, there has been an elevation of health matters to a national social issue during the 1970's. Closely related is the rise of "chemophobia," which, in the public mind, connects chemicals with cancer.

Cancer definitely is perceived as the biggest health problem. Today, say the polls, 80% of the public believe smoking cigarettes causes cancer. In addition, 50% believe exposure in the workplace causes cancer and 50% believe food additives cause cancer. Furthermore, 44% believe insecticides, pesticides, and herbicides can cause cancer.

Another reason for heightened public concern, says Lindheim, is the "media circus." Contending with the media, Lindheim believes, has never been an industry strong suit, and he voices some doubt that corporate ads defending industry positions receive high regard.

Despite the negative public reaction to the chemical industry, there isn't a widespread distrust of chemicals per se. The polls indicate that the idea of zero-risk products isn't given much credence. There is a definite desire for informed risk in which the public is given enough information to be able to judge the risk and proceed accordingly.

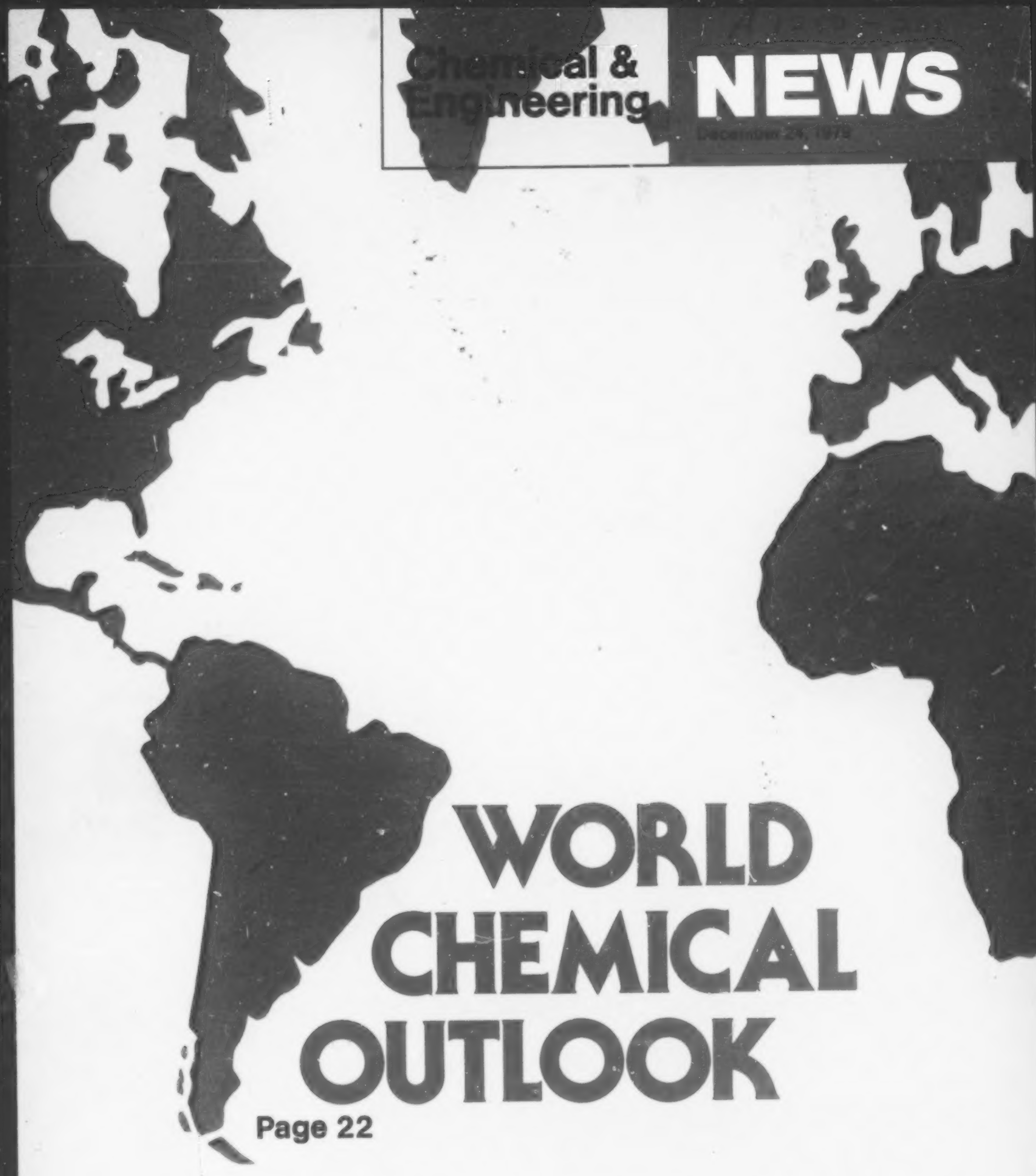
Lindheim believes that the worst of the chemophobia may be over, but there is still a very high degree of distrust to be countered by industry. Eventually, Lindheim says, it all boils down to a matter of trust. There is a need, he says, to tell the truth, be accessible to the public whenever possible, begin an auditing system for waste disposal, and to get the good record of industry before the public.

In presenting the industry's viewpoint, Richard Fleming, executive vice president of Air Products & Chemicals, notes that there is nothing new about risks with products. Most of the recent concern, he suggests, reflects some new perceptions, most of them incorrect. One that is properly perceived is that which recognizes that long-term exposure at very low levels can be dangerous.

However, Fleming says, it is totally wrong to believe, as some claim, that there is any real one-molecule mechanism for cancer causation. The rapid expansion of analytical techniques to very low detection limits has been a blessing and a curse. It has helped promote the one-molecule theories, he says, and also has been extrapolated to regulatory decisions without reason. Fleming believes the industry has suffered from the adoption of the no-risk philosophy in government regulation.

Fleming is strongly in favor of truth in the public arena, but he suggests that the chemical industry, in general, has been truthful in the past. Its safety record is extremely good. Its health exposure record is equally impressive. By and large its waste disposal record is good, although there have been some exceptions. But despite all these, the industry has not engaged in much public self-praise and that seems to be necessary to counter the often malign publicity by anti-industry groups. □

Chemical & Engineering NEWS
December 24, 1979



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News of the Week

- ***Suits seeking cleanup and monitoring*** *at chemical waste dumps in Niagara Falls, N.Y., have been filed against Hooker and Occidental.* **Page 4**
- ***R&D spending in the U.S. will rise*** *about 7% in 1980 in constant dollars to a record $61.8 billion, forecasts Battelle.* **Page 4**
- ***First in series of science and technology studies*** *with a rolling five-year outlook, funded by the National Science Foundation, has been published.* **Page 5**
- ***Fourth-quarter earnings at Cyanamid*** *will be about $44.5 million—little more than the same period in 1978—or about 93 cents a share.* **Page 5**
- ***Recent diabetes research*** *in autoimmunity with animal models may boost experimental treatment of human juvenile-onset diabetes with immunosuppressant drugs.* **Page 6**
- ***Demand for chemists graduating next June*** *will be up only modestly in 1980; starting salaries will rise, but won't keep pace with inflation.* **Page 6**

Business

- ***Survey of chemical company pension*** *plans finds that they are in safer financial shape and are more generous than those of U.S. industry as a whole.* **Page 6**

Government

- ***S. David Freeman, chairman of TVA,*** *has increased the utility's emphasis on renewable energy resources, and would like TVA to be national lab for energy.* **Page 6**

Science

- ***DNA can form a left-handed helix*** *is the surprising finding of MIT scientists doing x-ray studies on small G-C sequences; configuration may give clues to how DNA reacts with other molecules.* **Page 14**
- ***Women scientists are making gains*** *with respect to their male counterparts in receiving equal status and pay, but several studies indicate that there are still many differences to be resolved.* **Page 15**

Education

- ***Trial has begun in the case*** *of alleged plagiarism by Solomons of material from the organic chemistry textbook of Morrison and Boyd; each side as distinguished chemists to testify for them.* **Page 18**
- ***Industrial chemists are teaching*** *analytical chemistry in VPI program aimed at providing an overview of industrial applications not covered in conventional courses.* **Page 20**

World Chemical Outlook

- ***The world chemical industry*** *is closing its books on a year that was both busy and profitable, but soaring feedstock and energy costs, slackening demand, and increasing competition cloud the outlook for the year ahead.* **Page 22**

Books

- ***Chinese science policy*** *and how it is progressing is described by U.S. delegation that visited China last year.* **Page 48**

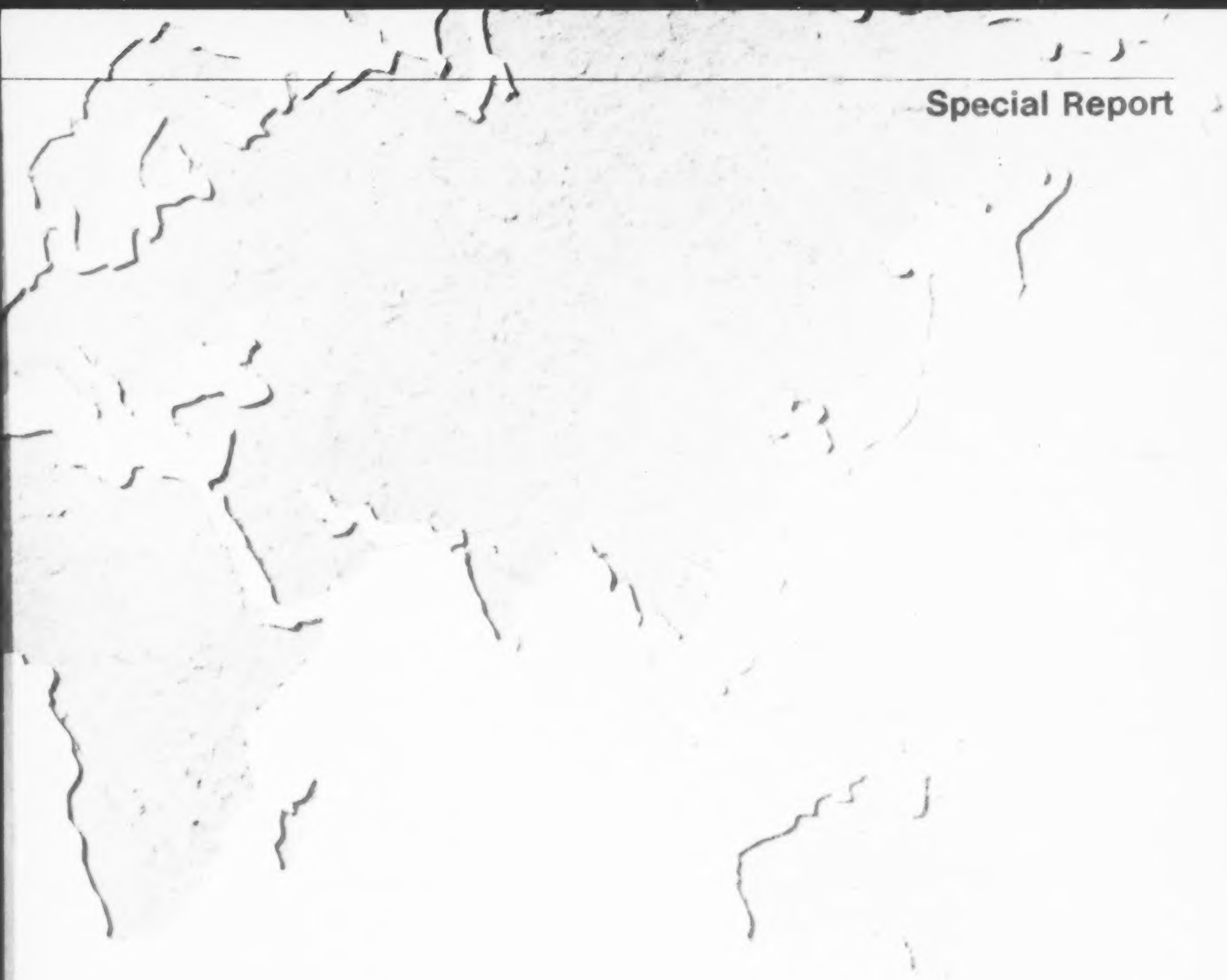
WORLD CHEMICAL OUTLOOK

More and more, the world's chemical industry is becoming integrated and closely knit. That this is true shows up clearly in this latest edition of C&EN's annual report on the outlook for the industry during the year ahead.

The rising cost of petrochemical feedstocks and energy, which in large part reflects continuing political turmoil in the Middle East, has driven up the expense of producing chemicals everywhere in the world. Nowhere is this more evident than in the price Western European petrochemical producers must pay for their basic raw material, naphtha.

At the same time, U.S. producers are enjoying a distinct cost advantage, at least currently, with hydrocarbon raw materials produced within this country. Couple this with the additional advantage of a dollar that is relatively weak compared with most other world currencies, and the upshot is a more strongly competitive position for U.S.-bred chemicals in markets throughout the world. The consequent rise in U.S. exports has provided a cushion for U.S. industry during a time when domestic demand has shown signs of slackening, even as it has caused consternation elsewhere.

Meanwhile, more and more countries are striving to develop a home-grown chemical capability. In Latin America, Mexico and Brazil already are factors to be reckoned with in world



chemical production. The Soviet Union and its Eastern European allies are aggressively seeking a place in the world chemical sun. Although their impact will be further in the future, China and the oil-producing countries of the Middle East are laying ambitious plans. Industry planners will ignore them only at increasing risk.

All in all, the year now closing basically has been a good one—in terms of production, sales, and profits—for the world's chemical industry. But now, with the U.S. apparently slipping into a business recession, industry executives everywhere are cautious. An economic slowdown in the U.S. probably would have an immediate impact on nearby neighbors like Canada and Mexico. But its effects could ripple across the economies of the rest of the world as well. Burdened as it is with fast-rising raw material costs, more slowly growing demand, and increasing competition, the world's chemical economy probably is more fragile than last year's buoyant record might suggest.

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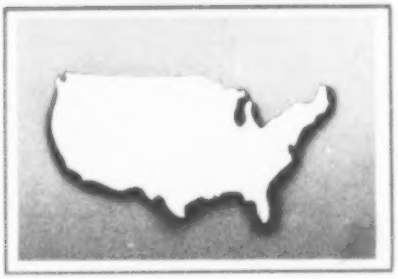


Chemical firms face business slowdown in 1980

The surge in sales and profits which the chemical industry enjoyed this year is unlikely to be repeated in the next 12 months

David M. Kiefer, C&EN Washington

The year now ending has proved to be much better for the U.S. chemical industry than generally had been expected 12 months ago. Then, the outlook for 1979 looked decidedly bumpy. Many economists were predicting that the U.S. would slip into a recession sometime before year's end—and probably before midyear. As a result, output of chemicals was expected to show little, if any, growth and profits to stagnate. In fact, many Wall Street observers were looking for a marked drop in chemical companies' earnings, on the average.

It didn't turn out that way at all. This month closes a year that was fundamentally strong for the chemical industry. Production is higher almost across the board. And with selling prices marked up repeatedly throughout the year, dollar sales have surged. For the year as a whole, sales for producers of basic chemicals, plastics, and fibers probably will top those of 1978 at least 20%. Profits, meanwhile, are running well ahead of the previous year. For the first nine months of 1979, they were about a third higher; for the entire year the gain will be nearly as much. It has been a particularly robust year for export markets. Plastics also have done well.

Industry executives, meanwhile, seem to remain optimistic, if cautiously so, about the 12 months immediately ahead. But if 1979, in retrospect, came up much more of a winner than had been forecast, 1980 may well prove more troublesome than many now think.

Economists, for one thing, are nearly unanimous in predicting a recession for 1980, with the consensus expecting a moderate decline extending at least into summer, to be followed by a rebound during the final months. Many economists are convinced, indeed, that the weight of the evidence indicates a business decline already is under way. The prestigious economic forum of the Conference Board states flatly, for example, that "the U.S. economy is in the grip of recession and it will run into the summer of 1980." The forum, made up of 12 economists and business analysts, projects real (adjusted for inflation) gross national product will fall 1.7% in the current three months, 1.8% in the first quarter of 1980, and 0.5% in the second quarter before recovering slowly during the year's second half. For 1980 as a whole, it forecasts a decline in real GNP of 0.4%, after a 2% rise this year.

Other economists are even more pessimistic. The Business Council, for instance, looks for a decline of 1.2% for all of 1980 in the total output of goods and services, after adjusting for price changes. Others think that 1980 will witness a year-to-year drop of 2 to 2.5% in real GNP.

The economic experts have been wrong in the past, to be sure—notably during the past 12 months, when predictions of impending recession have been persistently premature. Calling the turn of a business cycle has never been easy. Even now, the signals are by no means clear. The rate of unemployment shows no sign of rising; at 5.8% of the nation's labor force in November, it has held essentially unchanged for more than a year. Retail sales, too, are holding up, setting an all-time high of $77 billion last month. These and other indications of continuing economic strength are convincing some prognosticators that the economy is due for nothing worse in 1980 than a period of weaker, but lingering, growth.

One thing is clear nevertheless. Economic expansion already has slowed quite perceptibly from what it was in 1977 and 1978. Industrial production, for example, now is no higher than it was about a year ago; it has been flat all year. This year as a whole is expected to show a rise of about 4% compared to 1978, a gain, however, that may be largely wiped out in 1980.

And some major areas of business already are hurting severely, none more so than the automobile industry. Car sales at present are running about 20% behind what they were a year ago and Detroit has been cutting back drastically on its assembly lines in an attempt to bring badly swollen inventories into line with sales. As a result, about 130,000 auto workers are on indefinite layoffs, with even more likely to be off the job in any given week because of temporary shutdowns. Auto output is estimated to total 8.4 million units this year, down about 8% from 1978. And next year, according to some industry analysts, production is likely to slump again as much as 1 million cars.

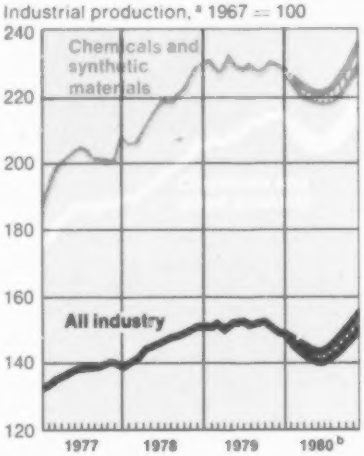
Housing is the other major segment of the economy for which near-term prospects are notably gloomy. With mortgage money in short supply and extraordinarily costly, housing starts are declining. Last year, 2.0 million new housing units were started in the U.S.; this year the total will be about 1.7 million (which is more than most housing experts were predicting at the start of the year). Next year, builders fear, only between 1.2 million and 1.4 million units may be started, and some warn that business may be even worse.

Other forms of construction, although generally holding up better than housing, also are expected to suffer from tight money and high costs. The Department of Commerce, as a result, forecasts that construction spending next year will be virtually the same as the $222.5 billion it estimates will go into new construction this year. However, that will mean that the physical volume of building will be 9 to 10% less.

The current weakness in autos and housing is sure to spread to other industries. Steel production, for one, probably will fall about 10 million tons in 1980 from this year's expected output of close to 100 million tons. Tire production, probably down 9 to 10% this year, is likely to be hit by a similar decline in 1980. Household appliance shipments are expected to decline 4 to 5%, actually a decline of 11 to 13% after factoring out the impact of higher prices. Textile production probably will hold up better next year than often has been the case during past recessionary periods, such as 1974–75, thanks in part to the absence of inventory excesses and relatively good export demand. Nevertheless, industry experts see textile mill activity easing about 2% from this year's levels.

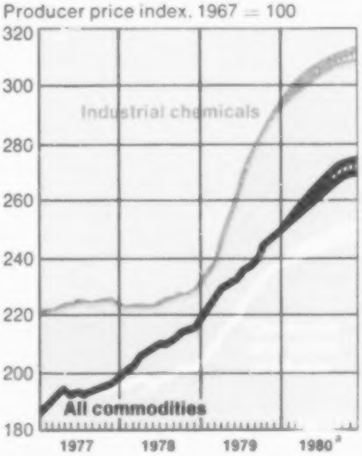
Nor will the chemical industry be immune. Autos, housing, appliances, tires, and textiles are among the major outlets for plastics, fibers, rubber, coatings, and other products turned out by the industry. Any

Production is likely to slump, then rebound, next year . . .



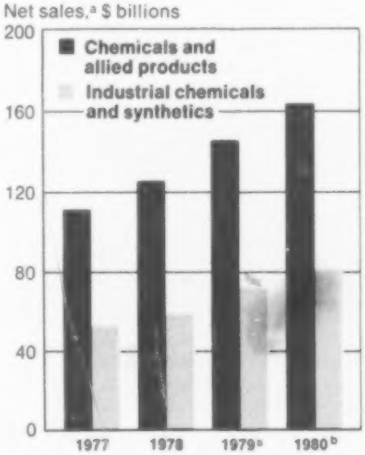
a seasonally adjusted. b C&EN estimates.
Source: Federal Reserve Board

. . . but selling prices will continue to rise . . .



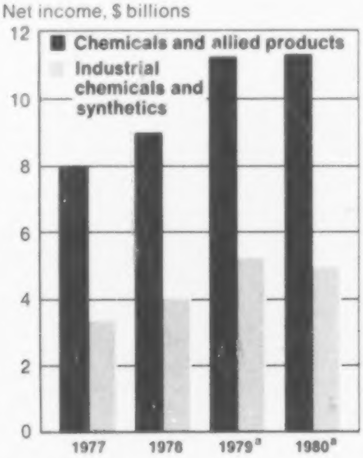
a C&EN estimates.
Source: Bureau of Labor Statistics

. . . giving another boost to sales volume . . .



a Excludes sales of foreign subsidiaries. b C&EN estimates. Source: Federal Trade Commission

. . . while profits fail to keep pace



a C&EN estimates.
Source: Federal Trade Commission

Little or no growth likely in production of most chemicals next year

	1977	1978	1979	1980
INORGANIC CHEMICALS (Thousands of tons unless otherwise noted)				
Ammonia	17,576	16,967	17,500	18,000
Chlorine gas	10,573	10,959	12,100	11,500
Hydrochloric acid	2,721	2,751	2,900	2,700
Nitric acid	7,951	8,061	8,500	8,200
Oxygen, billions of cu ft	393	428	430	450
Phosphoric acid	8,958	9,563	10,100	10,500
Sodium hydroxide	10,933	10,746	12,200	11,900
Sulfuric acid	35,821	39,857	41,800	40,500
ORGANIC CHEMICALS (Millions of lb unless otherwise noted)				
Acetic acid	2,570	2,776	3,200	3,000
Acetone	2,219	2,052	2,400	2,300
Acrylonitrile	1,646	1,752	2,000	2,100
Benzene, millions of gal	1,436	1,488	1,650	1,550
Butadiene	3,259	3,515	3,500	3,200
Cumene	2,644	3,380	3,600	3,500
Cyclohexane	2,265	2,332	2,400	2,300
Ethylene	25,426	25,955	29,500	31,000
Ethylene glycol	3,675	3,904	4,400	4,400
Formaldehyde	6,046	6,381	6,450	6,200
Methanol	6,453	6,443	6,900	6,500
Phenol	2,338	2,682	2,850	2,700
Phthalic anhydride	926	978	1,050	975
Propylene	13,328	14,375	15,600	16,500
Styrene	6,867	7,186	7,500	7,500
Toluene, millions of gal	1,018	1,054	1,450	1,400
***o*-Xylene**	985	1,013	1,050	1,000
***p*-Xylene**	3,172	3,516	4,200	4,000
PLASTICS (Millions of lb)				
Polyethylene, high-density	3,652	4,201	5,000	5,400
Polyethylene, low-density	6,471	7,111	7,700	8,200
Polypropylene	2,747	3,074	3,900	4,400
Polystyrene	3,446	3,823	4,000	4,100
Polyvinyl chloride	5,253	5,723	6,100	6,300
SYNTHETIC FIBERS (Millions of lb)				
Acrylic and modacrylic	709	726	750	700
Nylon	2,326	2,550	2,700	2,600
Olefin and vinyon	635	692	740	700
Polyester	3,642	3,800	4,200	4,000

Sources: Bureau of the Census, International Trade Commission, Society of the Plastics Industry, Textile Economics Bureau, C&EN estimates (for 1979 and 1980)

weakness in these areas can spill over quickly into chemical operations.

Actually, growth in production of chemicals and synthetic materials has been slowing all year, after having risen stoutly throughout nearly all of 1978. It probably peaked last summer and now is no higher than it was last winter.

For the year as a whole, production of chemicals and synthetics probably will wind up about 7% higher than in 1978. That's a good gain, about equal to what the industry achieved in 1978 and in line with its growth record over the entire past decade. If the current consensus that the U.S. is slipping into a brief and moderate recession proves true, chemical output can be expected to sag as well. For 1980 as a whole, production of chemicals and synthetics is likely to trail this year's level 2 to 3%, although a year from now it probably will be edging once again above its current level.

One factor that has helped to keep production at a high level this year is rising foreign demand for U.S.-made chemicals. Exports of chemical products will be about a third higher this year than they were in 1978, rising to about $17 billion. Relatively low petrochemical feedstock costs have given U.S. producers of organic chemicals, plastics, and fibers a competitive advantage over producers in Europe and Japan, where naphtha prices, for example, have been soaring. U.S. industry officials are hopeful that the advantage will hold up again next year, thus providing a cushion against the slack that will result from lower demand by U.S. customers. That perhaps too optimistic hope rests on the assumption, however, that demand abroad will not be hit by recession, as well.

Export demand has not been the only factor bolstering industry sales this year, however. Higher selling prices have been an even bigger factor. The Bureau of Labor Statistics' index for industrial chemical prices has been rising well over 1% a month throughout 1979, as producers have been compensating for sharply higher costs of energy and hydrocarbon feedstocks. Since plants making many basic petrochemicals and polymers have been running close to capacity in recent months, producers have been in a more favorable position than in the past to push higher costs successfully through to their customers. At present, the BLS index for industrial chemical prices is about 25% higher than a year ago. For the year as a whole, the gain probably will average about 17%. Synthetic resin prices, meanwhile, are now about 30% higher than this time last year, synthetic fiber prices between 10 and 15% higher.

Feedstock costs are bound to rise again next year. So chemical companies will have no choice but to hike selling prices still further, even though reduced demand may moderate the increases, at least during the early part of the year. Even so, prices next year are likely to average about 15% higher than this year.

This means that dollar sales, too, will be higher, whether production declines or not. Sales of chemical companies are likely to be up 20 to 25% this year, a much better showing than had been expected at this time a year ago. Next year, however, the gain may be only half as much.

Earnings are much more difficult to predict. For industrial chemical producers, the combination of higher prices and high plant-operating rates has made the past year unexpectedly profitable. No one expects a replay in 1980. But opinion is divided as to whether profits will hold at this year's high level or whether they will be eroded by a combination of weakening demand and constantly rising costs. The best bet now seems to be that earnings, at least during part of 1980, will compare unfavorably with year-earlier results. For the year as a whole, they are likely to trail 1979 profits about 4 to 6%—perhaps even 10% if recovery is delayed. But a repeat of 1975, when profits of producers of industrial chemicals, plastics, and fibers plummeted nearly 20%, hardly seems in the cards. ☐

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Foreign trade

U.S. chemical trade surplus widens

U.S. producers' cost advantages boosted exports in 1979, but uncertainties pose problems for the 1980's

Earl V. Anderson, C&EN New York

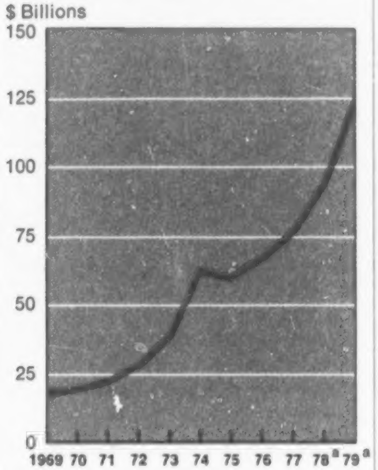
The U.S. chemical industry seems poised to jump headlong into a new decade of world trade from a springboard of unprecedented strength.

The industry will be coming off a year in which chemical exports are expected to hit a staggering $17 billion. The 35% growth of chemical exports in 1979 will be more than 2.5 times the increase in chemical imports, which are likely to rise 13% to $7.3 billion.

As a result, the last year of the 1970's will give the chemical industry a trade surplus enticingly close to $10 billion. That's quite an achievement compared to the $2 billion surpluses that the industry was ringing up when the 1970's began.

But a sound surplus isn't the only weapon chemical exporters will carry into the eighties. Like many other U.S. industries, the chemical industry is becoming more export-oriented. In more and more chemical companies, top management is becoming tuned in to the potential of exporting.

World chemical exports will top $100 billion this year



a C&EN estimates. **Source:** United Nations

The industry also likely will enjoy its well-documented feedstock advantage, at least for a few more years. Because of government price controls, petrochemical producers have been able to obtain feedstock at costs well below those of European and Japanese chemical companies. This factor alone played an important role in 1979's strong export performance.

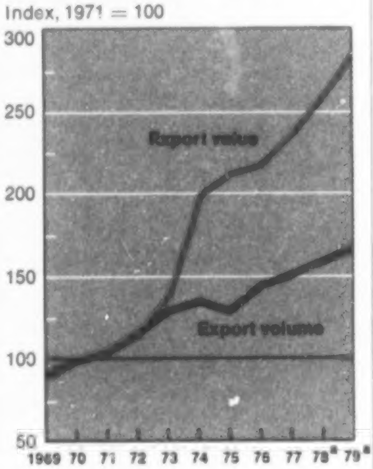
Starting next year, the world's major trading nations will be playing the game with a new set of trade rules—the result of the Tokyo round of multilateral trade negotiations concluded this year. A set of codes, covering such things as government procurement, subsidies and countervailing duties, standards, and customs valuation, is expected to help dismantle some of the nontariff barriers that U.S. exporters face overseas. Tariffs, although no longer the barriers they once were, nevertheless will be lowered on many chemical products.

Government, long considered as much of a hindrance as a help to U.S. exporters, may be providing more assistance. It is reorganizing the federal bureaucracy to put more emphasis on trade.

But the U.S. chemical industry won't be able to waltz into the eighties without its share of trade problems.

Its feedstock advantage, for instance, could be as troublesome as it is advantageous. Already, the European Economic Community (EEC) is

World exports: value leaps while volume creeps



a First-half average. **Source:** United Nations complaining about the flood of fiber and petrochemical imports entering member countries from the U.S. Calling U.S. oil price controls an "unfair subsidy," European countries want EEC to refer the problem to GATT (General Agreement on Tariffs & Trade). These companies think that countervailing duties should be slapped on these "subsidized imports." EEC already has imposed antidumping duties on American Cyanamid's acrylic fibers.

U.S. chemical exporters are afraid that EEC's action could set a dangerous precedent, one that could set a pattern of action against other U.S. chemical exports. And, even if U.S. chemical companies are able to sidestep this problem, they still have to face the fact that, eventually, their feedstock advantage will disappear as government decontrols oil prices and allows them to rise to world levels.

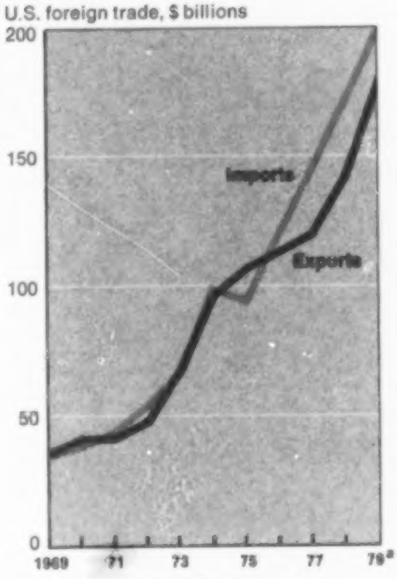
Although the Tokyo round agreements are history, there still remains the all-important question of how they will be implemented. William S. Sneath, chairman of Union Carbide, calls this "the real test." He sees a number of potential trouble spots and many trade experts echo his concern.

U.S. chemicals find growth markets in developing areas

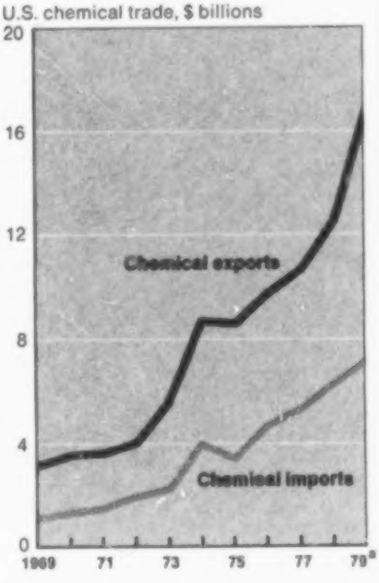
$ Millions	1979	1978ᵃ
CHEMICAL EXPORTS	**$17,000**	**$12,618**
Canada	2,003	1,739
Western Europe	5,432	4,275
Eastern Europe	204	62
Japan	1,624	1,104
Communist Asia	107	61
Middle East	386	367
Rest of Asia	2,226	1,324
Latin America	3,696	2,679
Australasia	552	417
Africa	444	349
Other	326	241
CHEMICAL IMPORTS	**$7,270**	**$6,427**
Canada	2,223	1,805
Western Europe	3,369	3,227
Eastern Europe	104	78
Japan	626	563
Communist Asia	53	34
Middle East	44	41
Rest of Asia	144	124
Latin America	400	312
Australasia	158	115
Africa	45	46
Other	104	82

a C&EN estimates. **Source:** Bureau of the Census

U.S. trade deficit narrows slightly this year...



... as its chemical trade surplus widens a lot



a C&EN estimates. **Source:** Bureau of the Census

These same experts wonder about the advantages of the tariff cuts negotiated at the trade talks. They think the cuts will do little to increase U.S. chemical exports, but could do much to increase U.S. imports.

Some problems that lie ahead for U.S. chemical industry in the 1980's are uniquely chemical. Others the industry shares with other segments of U.S. business.

So far, the chemical industry, along with other industries, has enjoyed the advantage that a weak dollar confers on exports. But a weak dollar breeds inflation at home. Investments in plant and equipment falter. Research and development expenditures decline. Productivity lags. None of these developments make for a competitive export industry. And in the 1980's, U.S. exporters will have to be more competitive than ever.

The underlying reason is oil. As oil becomes more expensive, nations that rely heavily on oil imports will emphasize exports as the best way to offset their mushrooming oil import bills. Meanwhile, these nations will try to find ways of reducing other imports. As a result, competition in markets in the developing countries will intensify.

Meanwhile, more products will be entering the world export market from developing nations. This will be particularly true of the so-called "newly industrialized nations," such as South Korea, Taiwan, Singapore, Brazil, and Mexico. Toward the end of the eighties, competition from Middle Eastern oil-producing nations could become a new threat to chemical exporters.

In the 1980's U.S. exporters also will have to face even more competition from foreign, government-owned companies. These companies don't operate under the same rules that privately owned U.S. companies do.

To them, profits usually are not the primary consideration. Heavily subsidized and supported by government, their objective often is to keep unemployment low. Social issues are the big concern. And to keep their plants operating, state-owned companies attack export markets with prices a U.S. company can't match.

Government-owned companies aren't new. But they multiplied in the 1970's, and no doubt there will be more of them in the eighties.

Saving jobs in faltering industries is perhaps the major reason for the formation of state-owned companies, but it is not the only one. They help diversify a country's industrial base, stimulate domestic economic growth, and often are the only way a country can support high-risk ventures. Such reasons will be as valid in the eighties as they were in the seventies.

The U.S. chemical industry isn't the only one that will face such competition. About 55% of the steel production in noncommunist countries is owned outright by governments. State ownership is mounting in telecommunications, gas and oil, aluminum, and shipbuilding, to name a few.

But the chemical industry already is feeling the pressure. An estimated

35% of the world's low-density polyethylene capacity is controlled by state-owned companies. About a fourth of its capacity for ethylene oxide and derivatives also is controlled by them. According to one estimate, firms owned or controlled by foreign governments will provide the U.S. chemical industry with 50% of its export competition in petrochemicals, plastics, and fertilizers.

In the face of all this competition, the U.S. will be trying to increase its own exports to reduce its staggering balance of trade deficit. Throughout the seventies, that trade deficit ballooned to a cumulative $76.7 billion. No doubt, the chief culprit was the skyrocketing price of imported oil.

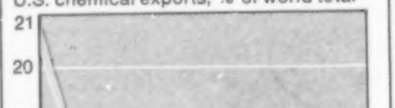
But it would be a mistake to blame the country's faltering stance in international trade on oil alone. And it may be worthwhile to take a long look back at the cause of the U.S.'s persistent trade problems.

According to many trade experts, the U.S. pursued an outdated international economic policy that lasted one decade too long. After World War II, U.S. policymakers focused, not on reparations, but on restoring Europe and Japan to economic health. Rightfully so. As no other nation before it, the U.S. used international economic policy to foster growth in other parts of the world.

World trade was an essential ingredient for this growth. Recognizing this, the U.S. embraced a liberal trade policy, orchestrated the world's leading trading nations into GATT, and established exchange rates that would stimulate the exports of other countries. Economic consequences weren't considered.

U.S. share of world exports remains at 10-year low

U.S. chemical exports, % of world total [a]



a Defined as U.S. exports as per cent of world chemical exports less U.S. imports. b C&EN estimates.
Source: United Nations, Bureau of the Census

Huge cost of imported petroleum. . .

U.S. petroleum imports	1979[a]	1978	1977	1976	1975	1974
All petroleum products						
Volume (millions of bbl)	3080	2970	3183	2646	2186	2231
Value ($ millions)	$52,660	$39,526	$42,368	$32,226	$25,197	$24,668
Unit value ($ per bbl)	$17.10	$13.31	$13.31	$12.18	$11.53	$11.06
Crude and partly refined petroleum						
Volume (millions of bbl)	2515	2399	2540	2066	1661	1466
Value ($ millions)	$42,800	$32,232	$33,910	$25,653	$19,293	$16,546
Unit value ($ per bbl)	$17.02	$13.44	$13.35	$12.42	$11.62	$11.29

. . . spoils an otherwise strong U.S. trade position

$ Millions	1979[a]	1978	1977	1976	1975	1974
Total U.S. exports	$180,000	$143,575	$121,150	$114,807	$107,130	$97,908
Fuels exports[b]	5,300	3,878	4,184	4,226	4,465	3,442
Total exports without fuels	**$174,700**	**$139,697**	**$116,966**	**$110,581**	**$102,665**	**$94,466**
Total U.S. imports	$200,000	$172,026	$147,685	$120,677	$96,116	$100,251
Fuels imports[b]	55,000	42,105	44,537	33,996	25,476	25,427
Total imports without fuels	**$145,000**	**$129,921**	**$103,148**	**$86,681**	**$69,640**	**$74,824**
Actual trade balance	−$20,000	−$28,451	−$26,535	−$5,870	−$11,014	−$2,343
Trade balance without fuels	$29,700	$9,776	$13,818	$23,900	$33,025	$19,642
Petroleum imports as a % of total imports	26.3%	23.0%	28.7%	26.7%	26.2%	24.6%

a Full year, estimated from 10-month data. b Mineral fuels and related materials (SITC section 3). Exports are primarily coal. Difference between values of fuels imports and exports of "all petroleum products" is primarily value of natural gas. **Source:** Bureau of the Census

In retrospect, say some trade analysts, the U.S. remained wedded to a policy that events have long outdated. By the end of the fifties, European and Japanese industries were producing with new and efficient plants. They once again had become significant factors in world trade. The U.S. share of world trade, as high as 50% at the start of the 1950's, dropped to 30% by the end of the decade.

But in 1958, when European currencies were made convertible, exchange rates were established that continued to overvalue the dollar. Overseas, U.S. exports ran up against a maze of nontariff barriers.

In the early 1970's, the consequences of this outdated international economic policy became apparent. The U.S. balance of trade surplus began to erode. In 1971, and again in 1972, it slipped into deficit. With the exception of only two years, it has been in deficit ever since.

In 1971, the U.S. was forced to suspend convertibility of the dollar. In 1973, the world's financial experts finally established a system of floating exchange rates. And the dollar has been buffeted since.

Despite the dollar's depreciation, and despite some half-hearted attempts at export promotion, the U.S. trade position has steadily declined throughout the 1970's. The U.S. started the seventies with a $2.7 billion trade surplus. It probably will end this year with a $20 billion deficit. And even that will be an improvement over last year's $28.4 billion.

Obviously, oil has helped lubricate the slide. This year, imports of all petroleum products will account for 26% of total U.S. imports. On a dollar basis, oil's share of total imports has exceeded 23% since 1974.

It's also true that, since the early seventies, the U.S. trade balance would have shown a consistent surplus had it not been for oil. But the fact remains that that surplus would have been declining since 1975.

Until this year. As a result of aggressive export marketing, total U.S. exports in 1979 will be about $180 billion. That's a 25% improvement over 1978. But it will take even more aggressive export marketing, coupled with realistic trade policies, for the U.S. to improve its trade position against the competition ahead. ☐

Western Europe's vintage year may not repeat

Western Europe

Business was strong in 1979 but rising costs and competition from imports are two big worries for 1980

Dermot A. O'Sullivan, C&EN London

For the West European chemical industry, 1979 will go down as something of a "vintage year." Demand was strong. Companies' sales advanced. Prices firmed. Profits were up.

This doesn't mean that industry leaders believe they have turned the corner. In the coming decade, they face a number of strategic imponderables. Not least among these are the severity of the recession now widely predicted and its effect on business, as well as the availability and price of oil and oil derivatives.

The latest annual economic report of the Commission of the European Communities opens on a somber note. "Expectations for 1980 have to be relatively modest," it states, "taking into account the rise in the price of oil in the past 12 months, and the current recession in the North American economy." There are, too, "many unresolved domestic economic problems" in the EC member states—Belgium, Denmark, France, West Germany, Ireland, Italy, Luxembourg, the Netherlands, and the U.K.

Among the key macroeconomic indicators, gross domestic product (GDP) underwent a 3.1% volume growth this year for the European Economic Community as a whole, matching that of 1978. Next year, however, only a 2% gain is foreseen. This will mean that EEC will fall short of its 1976–80 growth objective.

There are, of course, variations in the relative strengths of the economies among the individual EEC members. West Germany (GDP up 4.3%) and Ireland (up 6%) turned in the best performances this year. On the other end of the scale, the U.K. was the weakest, with a GDP gain of a mere 0.3%. Next year, the U.K.'s GDP is expected to decline 1%.

The unemployment rate has been edging up throughout EEC. This year, it stands at 5.6% of the labor force compared to 4.3% five years ago. Next year, the level of unemployment is expected to move even higher, to 6.2%.

Inflation, too, is a source of continuing worry. The increase for the year is pegged at about 9% for EEC as a whole. Belgium, West Germany, Luxembourg, and the Netherlands have managed to hold the rise in consumer prices below 5%. But double-digit inflation rages in Denmark, France, Ireland, Italy, and the U.K.

Nevertheless, this Christmas will be a reasonably happy one for exec-

Most European chemical firms report sharp profits gains

$ Millions	Sales	Change from 1978	Earnings before taxes	Change from 1978
Akzo	$4,606.6	13%	$245.6	80%
Albright & Wilson	389.6	0	21.5	−48
BASF	11,011.5	21	772.4	77
Bayer	11,306.3	14	673.0	44
Fisons	452.2	25	16.0	−36
Hoechst	11,376.4	10	712.6	49
Imperial Chemical Industries	8,525.7	17	908.9	24
Rhône-Poulenc	3,581.7	16	70.3[a]	100
Solvay	2,031.5	26	65.2[a]	57
Unilever	11,679.3	12	704.7	9

a Net profit after taxes. **Note:** Data are for nine months ended Sept. 30, 1979, for Akzo, BASF, Bayer, Hoechst, and Imperial Chemical Industries, and for six months ended June 30, 1979, for Albright & Wilson, Fisnns, Rhône-Poulenc, Solvay, and Unilever.

utives of most West European chemical companies. Business has turned out to be considerably better than they had anticipated a year ago. Even hard-pressed Akzo, of the Netherlands, after several years of operating in the red, has moved firmly back into profitability and has resumed paying a modest dividend.

For DSM, also headquartered in the Netherlands, an unexpected business pickup in the second half of the year ensures that it will round out 1979 with a small profit gain. Earlier, a loss had been forecast. DSM had registered a net loss of $18.5 million during the first half of the year.

France's Rhône-Poulenc ranks as one of this year's star performers among the West European chemical giants. Figures for the first half of the year show a net profit of $70.3 million, double that of the January-through-June period of 1978. Company president Jean Gandois indicates that net profit for the year might be as high as $170 million, three times last year's earnings. The improvement reflects both the overall strength of business as well as the effects of the sharp streamlining of the organization that has been under way since 1975, when the company was heavily in the red.

West Germany's three largest chemical concerns—BASF, Bayer, and Hoechst—also have good reason to be pleased with this year's turn of events. Comments of Matthias Seefelder, BASF's chairman, sum up the experience of the three companies. "The most surprising thing this year," he says, "is that the seasonal lull usual in the summer was essentially nonexistent. The fear of the holiday slump period proved unjustifiable."

North Sea oil contributed to Imperial Chemical Industries' 17% advance in sales and 24% gain in pretax profits for this year's first nine months. ICI has a 19.2% stake in the Ninian field that began producing commercially this year.

The overall improvement in the financial picture of the West European chemical companies reflects both a strengthening in volume of products sold and an improvement in pricing. For BASF, roughly two thirds of the increase in sales can be attributed to greater volume, and one third to higher prices.

The fact that the high level of demand for a wide spectrum of chemical products continued unabated throughout the year took most people by surprise. It had been assumed that the upturn of orders that began in the fourth quarter of 1978 reflected a buildup of inventories as a hedge against anticipated price increases, a buildup that would tail off around midyear. Although undoubtedly there has been some restocking, the consensus is that this hasn't occurred at anywhere near the degree that it did in 1974.

Because demand was buoyant and continuous throughout the year, companies achieved better utilization of plant capacities. This, in turn, shaved operating costs.

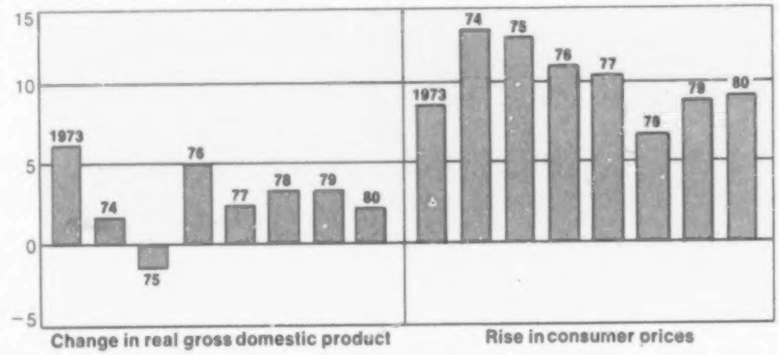
Welcome as the higher throughput of plants has been, there still is considerable room for improvement. West European petrochemical units generally have been underutilized in recent years. And it's expected that this state of affairs will persist for the coming five years at least.

In 1978, for example, the latest year for which firm data are available, overcapacity resulted in petrochemical plants operating at less than 80% of nameplate capacity. Operating rates generally were between 70 and 75%. Plants making acrylonitrile-butadiene-styrene and polystyrene generally have fared worse.

This condition is not likely to change much next year. Indeed, output of caprolactam and ethylene, as a percentage of installed capacity, is expected to slip below 70%. By 1985,

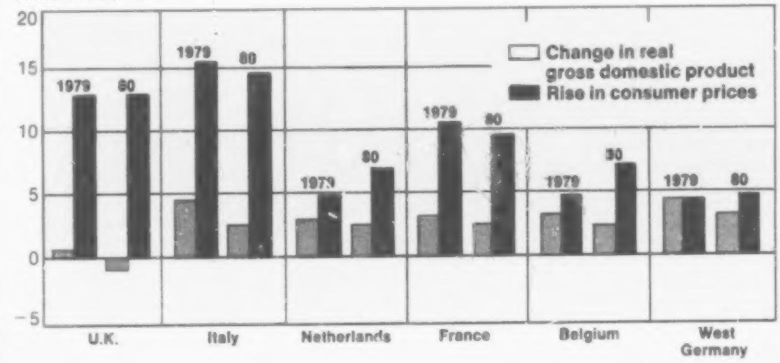
Slower growth, more inflation forecast for Europe . . .

Annual rate, %, for European Communities economy



. . . with the outlook especially dim for the U.K.

Annual rate, %



Source: Commission of the European Communities however, the situation is expected to improve, with ethylene plants running at about 78% of capacity and only a few products being produced at rates less than 75% of capacity.

The rise in feedstock and energy prices and labor costs throughout the year added to operating expenses. In Western Europe, the contract price of naphtha, which was just under $160 per metric ton last January, has risen to between $295 and $310 per metric ton. The spot price of naphtha, meanwhile, has doubled from about $193 per metric ton last January to $385 per metric ton now. There is every reason to expect that the rise will continue.

Their greater outlays for raw materials and energy have helped chemical companies push through price increases this year. In fact, the higher price tags attained more than compensate for the higher production costs to date.

A major concern for the 1980's is the apparent inevitability of further rises in the cost of raw materials. Against the background of meager economic growth expected in the near term, it's questionable whether there will be much room for boosting prices to consumers. The prices of oil and gas derivatives are bound to keep on going up, nevertheless. Moreover, availability of hydrocarbons could be seriously threatened if the current political unrest in the Middle East persists and widens.

Knowledge that oil and gas exist under the North Sea provides some modicum of consolation. Prices of oil and gas produced there, of course, will move in step with the price of oil and gas from other sources. Nor are the quantities being produced sufficient to meet Western Europe's entire demand, but it's reassuring, at least, to know of their existence.

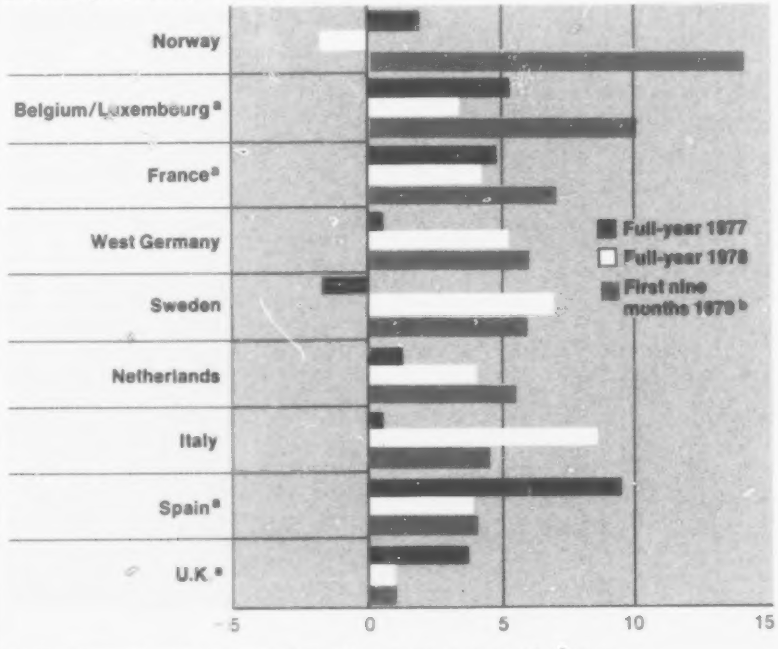
Exploitation of North Sea hydrocarbons ranks as one of the most outstanding technical achievements of this past decade in Europe. The first significant discovery of offshore oil was made just 10 years ago in the Norwegian sector by a consortium led by Phillips Petroleum.

Intensive well development and pipe-laying activities ensued. The Norwegian Ekofisk field began yielding oil in 1971. In 1975, the first flow of oil by pipeline from the U.K.'s Forties field began. All told, there now are some 14 North Sea oil fields in production or under development.

Established petrochemical operations, such as those of BP Chemicals and ICI, are using North Sea oil and gas. But only two have emerged that are designed solely around this source of hydrocarbons. One is at Rafnes, in southern Norway. There, Noretyl—owned 51% by Norsk Hydro, 33% by the Norwegian-state-owned Statoil, and 16% by Saga Petrokjemie—has a cracker using natural gas liquids recovered from Ekofisk by Phillips at Teesside, England. (A deep seabed trench between the Ekofisk field and Norway prevents laying a connecting pipeline directly to the Norwegian mainland.)

Production is growing faster in much of Western Europe this year

Chemical production, % change from previous year



a Excludes synthetic fibers. b Estimated. Source: Chemical Industry National Federations

The other complex based on North Sea hydrocarbons still is on the drawing boards. It will center on an ethane cracker which Esso Chemical, Exxon's U.K. subsidiary, recently received U.K. government approval to build at Mossmorran, near Edinburgh, Scotland. When completed in 1984, the $700 million unit will be able to produce 1.1 billion lb of ethylene annually.

The Mossmorran cracker will be the first of its kind in Western Europe to operate on ethane. (To hedge its feedstock supply bets, Esso Chemical is building flexibility into the cracker to allow use of some propane). Ethane will be separated from a mixture of gases piped from the Brent oil and gas field (about 280 miles out in the North Sea) jointly owned by Exxon and Royal Dutch/Shell.

Shell Chemical will finance half the cost of the cracker and will have access to half the plant output for its existing operations at Carrington and Stanlow, England. Esso Chemical initially will ship its ethylene to its sister companies in continental Europe. But it's reasonable to expect that the availability of ethylene at Mossmorran will attract plants to the site to make use of it there.

An overriding concern among European chemical executives right now is the growing competitive edge that U.S. materials hold over those of European origin, not only in Europe itself but elsewhere. The threat of competition began to take force during the past few years as the value of the U.S. dollar weakened against major European currencies.

The slide in the U.S. dollar has been more pronounced against some currencies than against others. In the case of the West German deutsche mark, for example, the dollar was valued at 2.62 DM on Dec. 31, 1975. Today, it is about 1.75, only two thirds as much. Over the same time span, the Belgian franc and the Dutch guilder strengthened about 28%. The French franc changed less, gaining less than 10% against the dollar during the past five years. The cyclical movement of the more volatile British pound has meant that its overall shift against the dollar hasn't been so pronounced.

The effect of a weak dollar is that

U.S. goods become cheaper to buy in Europe. Europeans also point to the added advantage of lower per-unit manufacturing costs that their U.S. counterparts enjoy, stemming from larger, more integrated plants and less costly labor.

More recently, however, another factor has entered the equation. As hydrocarbon prices in Europe have increased, the differential between the controlled prices of U.S. oil and gas has widened. And there is every indication that the gap will become greater. Despite President Carter's move to deregulate U.S. domestic oil and gas prices, Europeans argue that it will take several years for the measures to take effect, and some are frankly skeptical that anything concrete will happen.

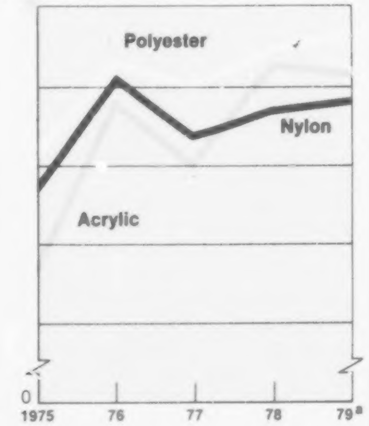
Exacerbating the situation is the current economic slowdown in the U.S. As U.S. demand for a variety of products weakens, so the reasoning goes, the tendency will be for U.S. producers to seek outlets abroad.

This already seems to be happening in the case of man-made fibers. Europeans are smarting at the arrival of increasing volumes not only of fibers as such but of textiles and finished goods.

According to figures compiled by Paris-based Comité International de la Rayonne et des Fibres Synthétiques (CIRFS), 30 million lb of polyester filament and yarn came into Europe from the U.S. during the first six months of this year. That exceeds the 27.7 million lb imported during all of 1978, which, in turn, was 41% more than in 1977. Imports of texturized polyester filament yarn, too, are going up—13.5 million lb in the first half of this year against 10.3 million lb in all of 1978 and 7.5 million lb in 1977.

Little growth for fibers

Production, billions of lb



a Estimated. Source: CIRFS (International Rayon & Synthetic Fibers Committee)

Western Europe hopes to boost operating rates in 1980's

Billions of lb per year	1978 Nameplate capacity	1978 Utilization rate	1980 Nameplate capacity	1980 Utilization rate	1985 Nameplate capacity	1985 Utilization rate
Ethylene	32.3	74%	37.9	69%	40.1	78%
Propylene	18.2	74	20.9	71	22.2	85
Butadiene	4.4	77	4.7	78	5.1	87
Styrene	7.6	75	8.1	74	8.6	84
Benzene	13.7	67	14.9	67	15.8	72
Acrylonitrile	2.8	75	3.1	72	3.1	82
Phenol	3.1	72	3.3	75	3.8	78
Caprolactam	1.9	75	2.1	68	2.1	76
Acetic acid	2.5	75	2.6	79	3.1	81
Vinyl acetate	1.3	73	1.4	84	1.6	90
Vinyl chloride	13.0	71	13.7	72	16.0	69
Polyvinyl chloride	11.5	73	12.4	73	14.0	73
Polyethylene, low-density	12.0	77	13.8	71	15.1	80
Polyethylene, high-density	4.8	74	5.4	72	6.3	75
Polypropylene	4.3	71	5.0	72	6.1	90
Polystyrene	6.0	67	6.4	69	6.5	76
Acrylonitrile-butadiene-styrene	1.2	62	1.3	60	1.6	69

Note: Nameplate capacity is greater than effective capacity. **Source:** Company data

Figures for acrylic staple provide another stark illustration. Here, too, the nearly 23 million lb of U.S. product imported into Western Europe from January through June of this year was more than last year's 22 million lb total, which itself was 41% ahead of the 1977 total.

Some countries are harder hit by U.S. imports than others. The U.K. has come up with some startling statistics. There, imports of U.S.-made polyester texturized yarn this year are likely to exceed 14 million lb, 240% more than in 1978. For 1978, the quantity swelled 1000% from 1977 to 4 million lb. Polyester staple imports from the U.S. this year will advance almost 560% (to more than 5.6 million lb) above the 1978 total.

Recent experience with vinyl acetate substantiates the concern. This year, upward to 190 million lb of the chemical will arrive in Western Europe from the U.S., about 40% more than in 1978, at a price considerably less than European-made product as a result of the lower cost of U.S. ethylene.

This is happening at a time when the man-made fibers business in Western Europe is far from buoyant. All the major producers have been cutting back their operations in the face of declining demand. Plant closures and deeper cuts in the labor force are likely to continue.

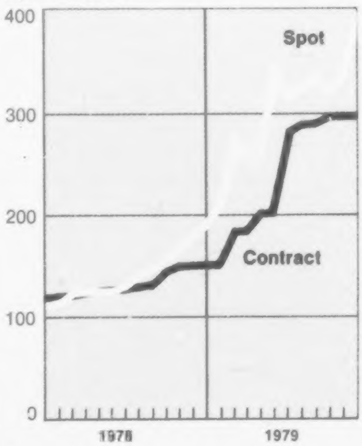
The European Council of Chemical Manufacturers' Federations (CEFIC) in Brussels is watching what is taking place in the man-made fibers business with growing alarm. The concern is that the trend might spill over into petrochemicals generally.

"The European chemical industry sees itself confronted by the threat of U.S. products being imported into Western Europe at prices with which [we] cannot compete," observed Jacques Solvay, CEFIC's incoming president, at the organization's annual assembly in Vienna last month.

Representatives of CEFIC and CIRFS have been keeping the EC Commission apprised of the situation. Etienne Davignon, the EC commissioner for industry, has been holding discussions with the U.S. at both government and industry levels. One avenue open to the Europeans if attempts to achieve voluntary restraint from the U.S. fail would be to initiate more formal action within the framework of the General Agreement on Tariffs & Trade. □

Naphtha prices are soaring

$ per metric ton



Source: *European Chemical News*

Rising raw material costs plague Japanese

Japan

Petrochemical producers had a good year in 1979 but still must meet the challenge of costly imported feedstocks

Earl V. Anderson, C&EN New York

Japanese chemical companies seem to be continuously climbing mountains—only to find another mountain on the other side. As they head into the last quarter of another fiscal year and the start of a new decade, Japan's petrochemical community is staring at a formidable obstacle.

The Japanese petrochemical industry was booming when the first oil crisis hit it in October 1973. In late 1974 and throughout most of 1975, it climbed its first mountain. With crude oil prices five times what they were and naphtha prices soaring, petrochemical output declined. Overall, production slipped 2% in value and even more in volume. Profits dropped or disappeared.

Last year, Japan's petrochemical industry faced a different obstacle, but a big one nonetheless. This time the mountain was price.

In 1978, petrochemical production increased. Ethylene output, for instance, was up 10%. Ethylene oxide production jumped 17%. Output of the major resins was significantly higher. But higher volumes of petrochemicals had to be sold at much lower prices. Resin prices declined 8% to 14%, depending upon type and grade. Among basic petrochemicals, the price of ethylene dropped 12%, propylene 22%, and benzene 21%. On average, the price of basic petrochemicals slipped 16%. Profits again were affected.

This year is different. For most of 1979, Japanese petrochemical producers have enjoyed a breather. Through the first eight months of 1979, production of most petrochemicals was way ahead of last year. Ethylene and propylene set the pace, with increases of 10 and 9%, respectively. Production gains for the major aromatics—benzene, toluene, and xylene—ranged from 7 to 9%.

Plastics output fared even better. Polyethylene production was 17% ahead of last year through the first eight months of 1979. Polystyrene was up 22%, polyvinyl chloride 36%, and polypropylene a whopping 41.5%.

In contrast to 1978, however, petrochemical prices also have increased substantially this year. In October, for instance, prices of a 40-chemical sampling rose 1.1%. According to the Ministry of International Trade & Industry (MITI), this put the average price of these chemicals 14.5% higher than it was in October 1978. The average wholesale price of petrochemicals increased in each of the first 10 months of 1979. Not one of the 40 chemicals sported a lower price in October than it did in January.

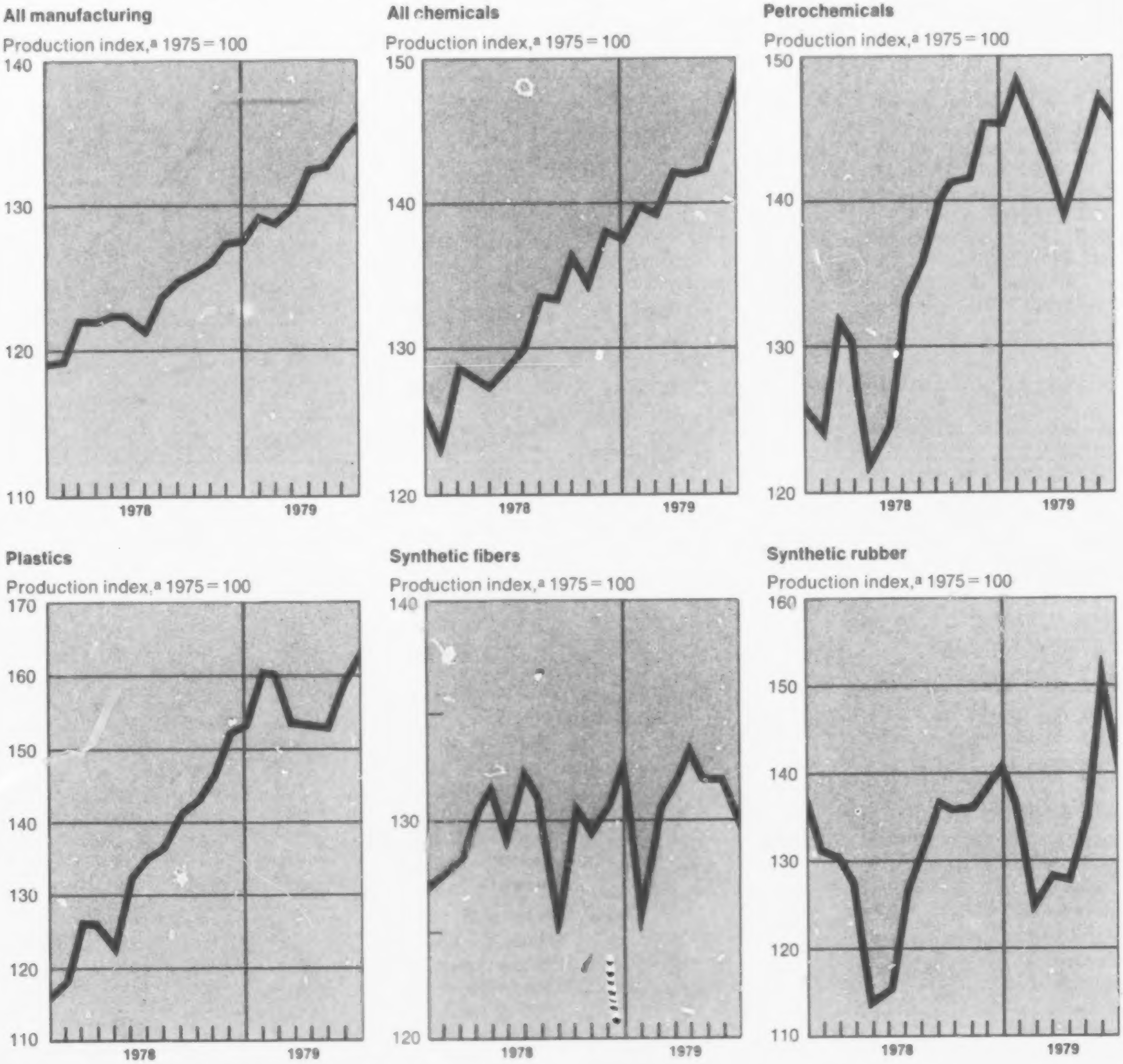
Meanwhile, Japan's major producers want to increase ethylene's price from 145 yen per kg to 160 yen (about 31 cents per lb at present exchange rates). If they are able to convince producers of ethylene derivatives to accept it, the price of

Both sales and profits are expected to be up in chemical process industries

% change from previous year	Sales		Operating profits	
	Fiscal 1980	Fiscal 1979	Fiscal 1980	Fiscal 1979
Chemicals	18.9%	3.2%	103.6%	206.9%
Pharmaceuticals	9.7	11.7	7.0	31.6
Paint and ink	13.7	5.6	16.5	57.2
Petroleum	23.0	−10.2	−242.8	−77.4
Rubber	12.0	5.1	18.3	20.9
Pulp and paper	15.7	−1.0	128.1	−1.0
All manufacturing	11.4	3.0	40.8	45.1

Note: Fiscal year ends March 31 **Source:** Nomura Research Institute

Production moves higher in Japan, with plastics buoying chemical output



a Seasonally adjusted. **Source:** Ministry of International Trade & Industry ethylene will increase for the sixth time since April and will have doubled in less than a year.

This year's combination of higher production and higher prices has had an equally pleasant effect on profits. According to a recent survey of 36 chemical companies, sales during the first half of fiscal 1979 (March through September) were up 13%, compared to the previous six-month period, but operating profits for the half-year were 43% higher than during the previous six months.

Now, however, another mountain has become visible and will be even more so in the first quarter of 1980. Overall petrochemical production may or may not decline, but it certainly won't grow so rapidly as it has this year. Sales growth also probably will taper off. According to the 36-company survey, sales in the six months ending next March are estimated to grow only 4.5%.

Barring another tremendous hike in naphtha prices, additional price increases in basic petrochemicals will be hard to push through. As a result, profits may be lower as the Japanese petrochemical industry heads into the new decade. Between March and September 1979, operating profits of the 36 companies surveyed rose 43%. But in the six months ending with March 1980, these companies expect profits to decline 5%.

Answers to a survey by the Japan Chemical Industry Association also reveal the changing attitude among chemical executives in Japan. They described business for most of 1979 in such terms as "very good" and "bright." But, starting in late 1979 and continuing at least through the first half of 1980, their collective attitude toward business prospects adds up to "rather depressing."

The basic reason most Japanese chemical executives feel uneasy about future business is the soaring prices of raw materials, particularly naphtha, and the difficulty in securing adequate supplies. Naphtha, in fact, has been the Japanese chemical industry's primary problem for several years.

Naphtha supplied to Japan under long-term contract now costs 55,000 yen per kiloliter. That's a hefty 90 cents per gal or about $35 to $36 per bbl, about 2.5 times higher than it cost at the beginning of 1979.

So concerned are Japanese chemical companies about naphtha that they have agreed with several European chemical companies to monitor prices. Possibly starting next month, participating Japanese and European companies will register their naphtha purchase prices with Klynveld Kraayenhof, a Brussels-based auditing company. Average prices and volumes will be released through the European Petrochemical Association.

With domestic supplies tight, Japanese chemical companies have been relying heavily on expensive imported naphtha. Over the past few months, however, they have been cutting back on imported material.

In October, for instance, naphtha imports were down 2.4% from September. More important, they were almost 19% lower than had been expected. An additional drop, perhaps as much as 6%, was expected in November. And there's little reason to believe that imports will go anywhere but down again this month.

There are several reasons for petrochemical producers' exercising restraint on naphtha imports. The principal one, of course, is cost. High prices on imported naphtha have boosted production costs. Another reason is that basic petrochemical producers are starting to switch to alternate feedstocks, such as liquefied petroleum gas and butane.

The mountain now lying ahead of Japan's chemical industry may not be so high as those it has climbed in the past. But it is trying to do everything it can to make the climb as painless as possible. □

Plastics pace growth in Japanese chemical production this year

Thousands of metric tons unless otherwise noted	1978	Eight months 1978	Eight months 1979	% change
INORGANIC CHEMICALS				
Ammonium chloride	718	473	488	3.2%
Ammonium sulfate	1929	1317	1259	−4.4
Calcium carbide	555	364	370	1.7
Calcium superphosphate	551	364	378	3.9
Carbon black	489	320	352	10.0
Chlorine, liquid	651	446	473	6.0
Hydrochloric acid	540	364	325	−10.7
Nitrogen[a]	3717	2476	2642	6.7
Oxygen[a]	6329	4162	4712	13.2
Sodium carbonate	1162	749	880	17.5
Sodium hydroxide	2777	1881	1918	2.0
Sodium silicate	654	432	469	8.6
Sulfuric acid	6437	4248	4332	2.0
Titanium dioxide	171	113	125	10.6
ORGANIC CHEMICALS				
Acetaldehyde	587	384	404	5.2
Acetic acid	518	340	347	2.1
Acetone	261	172	177	2.9
Acrylonitrile	609	406	393	−3.2
Benzene	2015	1331	1420	6.7
Butadiene	658	429	442	3.0
Butanol	222	139	165	18.7
Caprolactam	427	293	287	−2.1
Cyclohexane	477	324	329	1.5
Dioctylphthalate	265	177	165	−6.8%
Ethylene	4387	2834	3125	10.3
Ethylene dichloride	1837	1212	1345	11.0
Ethylene glycol	630	401	354	−11.7
Ethylene oxide	631	406	380	−6.4
Methanol	907	604	659	9.1
Octanol, synthetic	254	164	164	0
Phenol, synthetic	249	163	173	6.1
Phthalic anhydride	288	194	194	0
Propylene	2963	1915	2080	8.6
Propylene glycol	163	108	110	1.9
Styrene	1122	746	813	9.0
Terephthalic acid	590	368	424	15.2
Toluene	861	573	620	8.2
Toluene diisocyanate	61	41	41	0
Xylene	1248	827	899	8.7
Urea	2090	1366	1403	2.7
PLASTICS				
Phenolic resins	268	175	200	14.3
Polyethylene	1767	1201	1402	16.7
Polypropylene	745	460	651	41.5
Polystyrene	1032	654	798	22.0
Polyvinyl chloride	1204	736	1002	36.1
SYNTHETIC RUBBER	1028	679	731	7.7

[a] Millions of cubic meters. **Source:** Ministry of Trade & Industry

Mexico and Brazil have ambitious chemical plans

The two leading Latin American petrochemical producers are rushing headlong into the chemical big time

Earl V. Anderson, [illegible]

The Latin American petrochemical spotlight continues to shine brightest on Mexico and Brazil.

In Argentina and Venezuela, faltering chemical industries are trying to get back on the track. Argentina's petrochemical growth has been stunted by the country's sick economic conditions and by on-again-off-again investment policies.

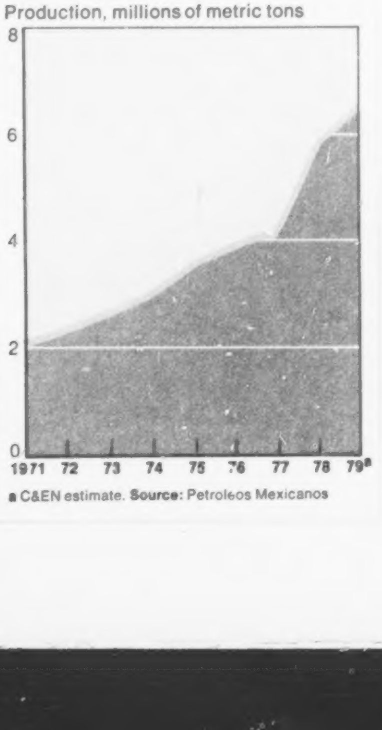
Now, however, the Argentine petrochemical industry finally may get rolling again. The country's new petrochemical promotion law permits private companies to participate in basic petrochemical output. New tax laws and preferred access to oil and gas feedstocks also are likely to stimulate petrochemical activity.

Venezuela's oil-based economy is sputtering under a heavy dose of discipline and austerity. "A mortgaged country" is how one economist describes Venezuela. Many businessmen who supported President Herrera's attempt to cool the country's overheated economy now wonder if he may have turned the thermostat down too far. Many huge development projects started by the previous government remain only partially complete. Inflation has driven up the cost of most of these projects.

Now Venezuela has a new policy designed to improve its economy. Most price controls have been lifted, which should allow chemical companies to earn a reasonable profit. Import restrictions have been lifted, too, although tariffs for most products are about 100%. Nevertheless, this likely will stimulate competition.

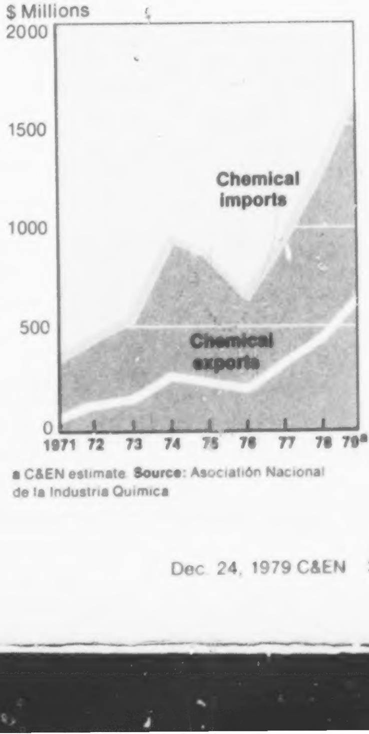
The one real indicator that the Venezuelan petrochemical industry is rolling will come when the troubled El Tablazo complex is operating at full capacity again. Presumably, this

Uptrend continues for Mexican petrochemicals



a C&EN estimate. **Source:** Petroleos Mexicanos

Mexico's chemical trade deficit widens



a C&EN estimate. **Source:** Asociación Nacional de la Industria Quimica will be by the end of the year. But El Tablazo has missed deadlines before.

Brazil and Mexico, too, have problems. But these problems haven't slowed down their headlong rush into the petrochemical big time.

The two leading Latin American petrochemical producers are building up their industries under entirely different circumstances. Mexico is oil rich; Brazil is oil poor and depends heavily on imports.

Mexico is riding the crest of an oil and gas bonanza. In the past three years, Petroleos Mexicanos (Pemex), the state-owned oil company, has discovered three major oil fields—in Bermudez, Cantarell, and Cicontepeo, Pemex drilled 188 test wells, hit oil or gas in 182 of them, and now is producing from 152.

Mexico's proven reserve of oil has grown to 45.8 billion bbl, with another 45 billion bbl listed as probable and 200 billion bbl as potential. The last may be conservative. Proven natural gas reserves are conservatively listed at about 60 trillion cu ft.

Recently, Pemex has been producing about 1.6 million bbl per day of oil and is expected to hit 2.25 million bbl next year. If it does, Pemex will be two years ahead of schedule.

It is upon this base that Mexico hopes to build its petrochemical industry. In Mexico, primary petrochemicals are the exclusive domain of Pemex. No private participation is permitted. Primary petrochemicals are defined as the basic building blocks, such as ethylene-propylene, the aromatic hydrocarbons, and their first-order derivatives. Thus, resins such as polyethylene and polypropylene fall to Pemex.

Pemex' basic petrochemical capacity now is about 8 million metric tons per year. But, with two major petrochemical complexes in the works, that capacity should increase to a tidy 18 million by the mid-1980's.

The first new complex already is being built at La Cangrejera, in Vera Cruz. At the core of the complex will be a 500,000 metric-ton-per-year ethylene unit. But La Cangrejera also will include capacity to produce propylene (240,000 metric tons), benzene (299,000), styrene (150,000), acetaldehyde (100,000), ethylene oxide (100,000), and low-density polyethylene (240,000). And there will be much more.

Construction at La Cangrejera is behind schedule, however. Probably the only units operating next year will be acetaldehyde and ethylene oxide plants, with perhaps an oxygen plant in addition.

The remaining units will have to wait until 1981. Meanwhile, Pemex plans to supply La Cangrejera with ethylene from its Parajitos plant until the La Cangrejera ethylene plant is operating.

By the time La Cangrejera is complete, Pemex will be looking ahead to another petrochemical complex at Morelos. Morelos also will feature a 500,000 metric-ton-per-year ethylene plant. It will include a battery of downstream units, including plants to produce 100,000 metric tons per year of high-density polyethylene and 100,000 metric tons of polypropylene.

Target date for completing the Morelos complex is 1982. But with the delays at La Cangrejera, Morelos may not be ready until 1983—perhaps later. Because of the lessons learned at La Cangrejera, Pemex expects construction at Morelos to go more smoothly.

Until most of the units at La Cangrejera come on stream in 1981, Pemex will have to get as much production as possible from its existing 8 million metric tons of primary petrochemical capacity. Last year, that output was almost 5.8 million metric tons, 37% higher than in 1977.

This year, Pemex' output of primary petrochemicals likely will increase about 11% to 6.5 million metric tons. Most of the increase will come from ammonia. No other major new capacity for primary petrochemicals has been operating. Pemex had hoped to produce almost 7.4 million metric tons of primary petrochemicals in

Production of chemicals is generally strong in Brazil this year

	First-half	Full year		
Thousands of metric tons	1979	1978	1977	1976
ORGANIC CHEMICALS				
Acetic acid	26	47	39	29
Acetic anhydride	12	25	26	—
Acetone	22	44	44	39
Benzene	112	172	145	121
Butadiene	57	81	81	81
Cumene	49	98	98	92
Dimethyl terephthalate	24	35	9	—
Ethylene	269	399	362	349
Ethylene oxide	41	40	31	28
Formaldehyde (37%)	64	118	115	125
Methanol	54	65	80	—
Phenol	36	70	71	64
Propylene	223	238	232	180
Propylene oxide	43	71	25	—
Styrene	85	145	64	62
Toluene	38	72	68	53
Vinyl chloride	47	106	108	94
Xylenes	77	93	70	50
INORGANIC CHEMICALS				
Ammonia	145	259	184	176
Ammonium nitrate	80	228	215	161
Ammonium sulfate	26	59	40	39
Carbon black	64	125	122	111
Chlorine	177	503	313	226
Hydrochloric acid	122	237	160	92
Nitric acid	126	353	341	374
Phosphoric acid	83	170	181	183
Sodium hydroxide	315	572	317	259
Sodium sulfate	34	64	62	79
Sulfuric acid	798	1578	1556	1439
Titanium dioxide	17	32	28	24
Urea	56	113	78	84
PLASTICS				
Polyethylene, high density	52	53	54	42
Polyethylene, low density	128	219	200	187
Polypropylene	41	25	—	—
Polystyrene	53	96	85	88
Polyvinyl chloride	87	173	160	152
SYNTHETIC ELASTOMERS				
Polybutadiene	15	33	33	23
Styrene-butadiene	77	158	146	130

Source: Abiquim (Associacão Brasileira da Industria Quimica e de Produtos Derivados)

Production was higher in Mexico last year for most chemicals

Thousands of metric tons	1978	1977	1976	1975
ORGANIC CHEMICALS				
Acetaldehyde	45	44	47	32
Acetic acid	57	36	25	39
Benzene	79	75	99	90
Dimethyl terephthalate	128	143	129	38
Ethylene	258	230	228	213
Ethylene dichloride	97	98	104	90
Ethylene glycol	56	49	42	45
Formaldehyde (37%)	48	42	40	33
Methanol	103	33	32	32
Propylene	138	138	114	93
Styrene	38	36	35	27
Terephthalic acid	55	49	28	5
Toluene	124	116	132	116
Vinyl chloride	56	56	60	45
Xylenes	76	62	66	52
INORGANIC CHEMICALS				
Ammonia	1579	944	865	801
Chlorine	175	172	143	127
Hydrochloric acid	97	80	72	69
Nitric acid	173	182	183	186
Phosphoric acid	346	392	363	392
Sodium carbonate	436	413	390	407
Sodium hydroxide	247	263	228	209
Sulfuric acid	2372	2296	2178	2047
Urea	156	179	161	155

Source: Asociacion Nacional de la Industria Quimica

1979. Operating problems, however, which a Pemex spokesman describes as "no big thing," probably will hold total production to only about 88% of the target.

Ammonia figures heavily in Mexico's petrochemical plans, both to supply the more than half the population working in agriculture and for export. Until 1977, Mexico had only 936,000 metric tons per year of ammonia capacity. That year, Pemex brought a 445,000 metric-ton-per-year unit on stream at Cosoleacaque. Last year, it added another 445,000-metric-ton plant there and started up a 300,000-metric-ton unit at Salamanca. Mexico has plans to build four more 445,000-metric-ton units.

Next year, Pemex hopes to increase its output of basic petrochemicals about 10%. With only two units—acetaldehyde and ethylene oxide—scheduled to come on stream at La Cangrejera, most of the increase will be again from ammonia.

Mexico's petrochemical buildup has other countries wondering if it will become a major factor in chemical exporting. It already exports huge amounts of ammonia. But significant chemical exports must wait until it sheds its still heavy dependence on imports. Last year, Mexico's chemical balance of trade deficit was $881 million. This year, despite increased ammonia exports, that deficit is likely to exceed $1 billion.

Like Mexico's, Brazil's first priority is to substitute domestic production for imports. Exports can come later. Not that Brazil doesn't export chemicals now. This year, for instance, its chemical exports will be about 38% higher than in 1978. But those exports will amount to a minuscule $275 million, with about 44% of them organic intermediates.

Chemical imports, meanwhile, will outdistance exports a factor of 10. Faced with a shortage of some plastics, particularly low- and high-density polyethylene, and a shortage of most aromatics, Brazil's chemical import bill this year will jump 40% to $2.6 billion.

This will give Brazil a $2.3 billion chemical trade deficit that it can ill afford. Brazil's overall trade deficit is soaring and probably will come close to $2.5 billion by year's end. Chief culprit is Brazil's dependence on imported oil. Through October, the country's imports totaled $14.4 billion. Oil accounted for $5.8 billion of that.

Brazil's trickle of chemical exports this year may surprise some international chemical traders. Last fall, virtually all of Brazil's second massive petrochemical complex (or "pole," as they are called in Brazil) came on stream. The $3.1 billion behemoth at Camacari, in the northern state of Bahia, may be the world's largest fully integrated petrochemical operation.

Only acrylonitrile and detergents plants are yet to come on stream. The acrylonitrile unit should be just about ready to begin operation. The detergents unit won't start until mid-1981.

Counting these two units, Camacari will be able to produce a staggering 3.6 billion tons per year of petrochemical products. The core unit is a 388,000 metric-ton-per-year ethylene plant that also can produce 200,000 metric tons per year of propylene and 130,000 metric tons of benzene. Downstream units include styrene (100,000), polystyrene (45,000), ethylene oxide (105,000), ethylene glycols (142,000), low-density polyethylene (100,000), and high-density polyethylene (60,000). There also is a 150,000 metric-ton vinyl chloride unit and a 140,000 metric-ton polyvinyl chloride plant.

The Camacari plants are helping to boost Brazil's petrochemical output this year. At the half-year mark, for instance, ethylene production was running at a rate of 540,000 metric tons per year, 35% ahead of 1978's pace. As much high-density polyethylene was produced during the first six months of 1979 as in all of 1978.

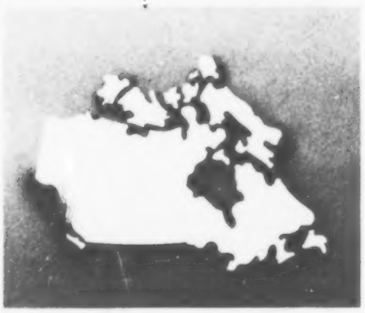
This burst in production, however, is not reflected in Brazil's chemical exports. The explanation lies in Brazil's unique domestic market for chemicals. The best word to describe Brazil's domestic market is "latent." It always seems ready and able to soak up new increments of capacity. Selling chemicals produced in Brazil seems to be no problem. "Our customers always seem to be waiting for it," says one chemical executive.

The domestic market already has caught up with Camacari's huge capacity. Low-density polyethylene is a good example. Last year, Brazil produced 218,000 metric tons and imported another 32,000 metric tons. This year, the 100,000 metric-ton unit at Camacari is operating at 120% of nameplate capacity. Yet it still hasn't shut out imports completely.

Brazil is starting to build its third major petrochemical pole, a $2.5 billion complex near Porto Alegre in the southern state of Rio Grande do Sul. At the heart of this complex will be a 420,000 metric-ton-per-year ethylene plant. This complex isn't scheduled to come on stream until mid- or late 1982. Some skeptics think it may be even later.

But most Brazilian chemical officials agree that it's already needed. Despite Brazil's economic problems—and they are awesome—chemical marketers there see no letup in demand for their products. □

Canada



Profitability improves for Canadian chemical firms

Low-cost raw materials and large-scale plants have improved chemical companies' operations but gains may fade soon

Ward Worthy, C&EN Chicago

For the Canadian chemical industry, 1979 brought a return to reasonable—although certainly not spectacular—levels of profitability. Real growth was modest, overall. But for the first time in four years, chemical makers, in many cases, could raise their prices enough to compensate for their own rising costs.

Petrochemical and plastics producers benefited from rising world oil and gas prices. The Canadians, with access to lower-cost domestic feedstocks and with new world-scale plants in operation, rather quickly became highly competitive in world petrochemical markets. Canada is now a net exporter of chemicals, and exports have contributed much to the improved earnings picture.

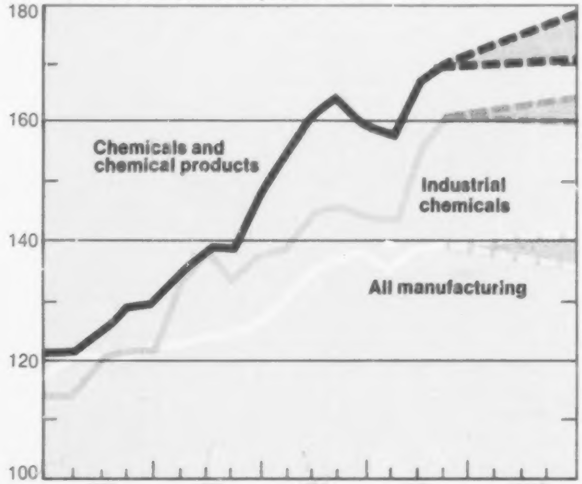
There are dark signs, however. Activity is leveling off or declining in many segments of the Canadian economy. Canadians naturally are concerned about the impact of the long-awaited recession in the U.S., where 70% of Canada's exports go. As 1979 ends, hardly anyone in the Canadian chemical industry is willing to predict that the good times will last.

Even though production gains were modest in 1979, chemicals still outpaced manufacturing as a whole. Over the past three years, output of chemicals has been growing about twice as fast as that in the total manufacturing segment. But the gap is narrowing. For 1979, the volume of real domestic product for the chemicals and chemical products industry will rise about 3.5% from 1978, compared to 2.5% for all manufacturing.

Chemical production actually dropped sharply in the first and second quarters of 1979 but rebounded more sharply in the third quarter. By

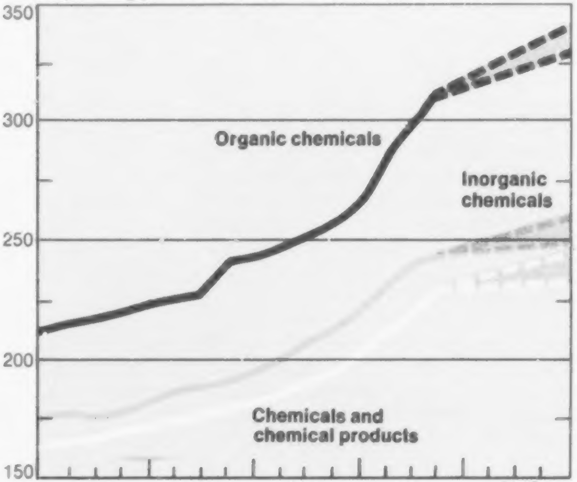
Chemical output will level off...

Volume index, real domestic product, 1971 = 100



...but prices will keep rising in 1980

Industry selling price index, 1971 = 100



a C&EN estimates. **Source:** Statistics Canada the end of the third quarter, however, the growth rate had leveled off again. For 1980, continuation of the long-term upward trend is about the best that can be hoped for.

Because of inflation, the dollar volume of shipments has risen at a faster rate than real production. Total shipments of chemicals and chemical products will amount to about $9.4 billion (Canadian dollars) this year, 18% ahead of 1978's $7.96 billion. If current trends continue, shipments will reach $11 billion in 1980.

As might be expected, some parts of the chemical industry have done better than others in 1979. Shipments of mixed fertilizers are running about 31% ahead of last year. But in 1978, they were 30% below the 1977 level. Other strong gainers include plastics and resins, up 29%; pigments and dry colors, up 31%; and industrial organic chemicals, up 43%. Industrial inorganic chemicals are only plodding along, with shipments up 8%.

Production figures for specific chemicals tend to confirm the trends indicated by the shipments data. Production of ammonia and sulfuric acid—the two most important chemicals, in terms of tonnage—has been slightly below 1978 levels. Chlorine and caustic soda output, on the other hand, is running about 10% ahead of last year.

In contrast to the generally lackluster performance of the inorganics, organic chemicals and plastics show big gains. Benzene production, for example, is up about 30% from 1978 levels, and formaldehyde output about 20%. Although ethylene output went up only about 7%, polyethylenes increased some 40%.

At the end of September, the selling price index for chemicals and chemical products had risen 15.2% from the year-earlier level. For some product categories, price increases are substantially above the average: mixed fertilizers, 19.0%; industrial organic chemicals, 18.9%; and plastics and resins, 18.2%.

Higher selling prices have had a marked effect on the profitability of the Canadian chemical industry. For the first nine months of 1979, sales by Canada's four largest publicly reporting chemical companies—Canadian Industries Ltd., Celanese Canada, Du Pont Canada, and Union Carbide Canada—were 26.5% higher than in the corresponding period of 1978. However, total net income for the four firms jumped 173.2%. The third quarter was particularly profitable.

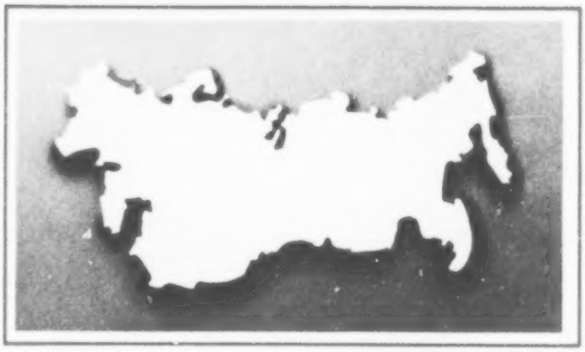
For the first nine months of 1979, profit margins for the four firms ranged from 4.4 to 7.6%, averaging a respectable 6.0%. In contrast, profit margins in the first three quarters of 1978 ranged from 1.7 to 4.0%, with an average of only 2.7%. The four companies expect that profitability will hold up well through the fourth quarter, but they're very cautious in their appraisals of 1980.

Particularly unsettling is the Canadian government's stated intention to increase domestic oil prices. How much the increase will be and how it will be carried out have yet to be revealed. But any sizable increase would wipe out the petrochemical industry's present competitive advantage in world markets. Petrochemical producers are urging special consideration for their industry. □

Production: growth is likely to slacken next year

Thousands of tons per year unless otherwise noted[a]	1976	1977	1978	1979[b]	1980[b]
Acetylene (mcf)	264.5	255.8	250.8	250	250
Ammonia, anhydrous	1530.5	2365.1	2583.1	2550	2600
Ammonium nitrate	1026.0	1019.4	985.9	1000	1000
Ammonium phosphates	1069.4	1264.7	1325.2	1500	1600
Benzene (tb)	2590.9	2741.1	3491.3	4500	5000
Caustic soda, 100% NaOH	1016.4	988.0	1142.2	1275	1200
Chlorine	990.2	979.2	1037.0	1125	1100
Ethylene	560.9	625.3	910.2	980	1000
Formaldehyde, 100% solids	67.3	73.0	80[b]	90	100
Hydrochloric acid, 100%	120.7	150.2	170.4	170	180
Oxygen (mcf)	3806.5	4295.5	5474.3	5800	6000
Phosphoric acid, 100% P_2O_5	576.0	554.7	563.2	750	800
Polyesters, unsaturated (mp)	40.5	46.1	44.7	60	60
Polyethylene (mp)	663.4	760.7	1052.7	1500	1650
Polystyrene (mp)	167.4	187.8	217.7	275	300
Polyvinyl chloride (mp)	213.3	219.8	275.0	325	375
Sodium chlorate	152.2	178.1	219.5	250	275
Sulfuric acid, 100%	3133.2	3461.6	3594.5	3500	3500
Urea	383.0	887.0	1341.7	1200	1300

a mcf = millions of cu ft, tb = thousands of bbl, mp = millions of lb. **b** C&EN estimates. **Source:** Statistics Canada



Chemical growth slows in U.S.S.R., East Europe

Shortages of energy, transportation, and manpower and low productivity impede industrial development

Richard J. Seltzer, C&EN Washington

The Soviet Union and its East European allies give high priority in their current five-year plans (1976–80) to the development of chemical industry. Much progress has been made. However, serious economic and industrial problems now besetting these countries also beset their chemical industries. The result is slower growth and failure in most cases to meet development goals—last year, this year, and probably for the five-year plans as a whole—with gloomy prospects for the 1980's as well.

The Soviet Union is the main supplier of raw materials and fuel to East Europe—furnishing, for instance, all East Germany's natural gas, more than 90% of its crude oil, and most of its iron ore and nonferrous metals. Energy investments and energy conservation campaigns are generally getting top priority. And all East Europe must worry about its petrochemical industry: Soviet oil—sold to it at less than current world prices—probably will reach a production peak in the next year or two and then rapidly decline, according to Central Intelligence Agency (CIA) projections.

The Soviet bloc already has set up a basic chemical industry and will continue to develop it. But more attention will go to higher-value-added chemicals such as specialty chemicals. For example, Romania's next five-year plan (1981–85) gives priority to specialized and fine chemicals, including pharmaceuticals (more than doubling 1980 output), dyes and pigments (up 60 to 80%), lacquers and paints (up 50 to 70%), pesticides (up 40 to 60%), detergents (up 80 to 100%), and cosmetics and perfumes (up 140 to 160%). To achieve this progress, East Europeans will try to acquire western technology.

Soviet and East European governments release only limited and selective data on their economic targets and results, and the figures must be regarded with caution. Nevertheless, it is known that the U.S.S.R. set a goal at the start of its current five-year plan of increasing chemical production 60 to 65%, or about 10.5% a year. This is the highest targeted growth for any Soviet industry.

However, according to CIA estimates, chemical production rose only 5.0% in 1976, 6.0% in 1977, and 3.1% in 1978. (These numbers are lower

Soviet Union's chemical output leads East Europe's by far

Thousands of metric tons in 1978	U.S.S.R.	Bulgaria	Czechoslovakia	East Germany	Hungary	Poland	Romania	TOTAL
Caustic soda (100%)[a]	2,764	102	309	415	154[b]	463	800	**5,007**
Synthetic ammonia[c]	11,300	960	817	1193	756	1610	2227	**18,863**
Sulfuric acid (100%)	22,400	974	1195	972	689[d]	3314	1619	**31,163**
Mineral fertilizers[e]	23,642[f]	968	1176	4604	847	2621	2461	**36,319**
Nitrogen fertilizer[e]	9,200[f]	685	625	885	533	1471	1715	**15,114**
Phosphate fertilizer[e]	6,085[g]	283	367[g]	413[g]	184	1026	682	**9,040**
Potassium fertilizer[e]	8,350[f]	—	184[h]	3306	130[h]	124[h]	64[h]	**12,158**
Plastics	3,517[i]	177	810	753	213	471	552	**6,493**
Synthetic rubber	1,795[j]	25	59	155	—	126	147	**2,307**
Synthetic fibers[k]	483	45	85	128	19	158	134	**1,052**

a Including tonnage used on site for processing. **b** Including regenerated caustic soda. **c** Nitrogen content. **d** Including oleum. **e** On basis of nutrient content (N, P_2O_5, or K_2O, respectively). **f** Including some product used for technical purposes. **g** Including production of ground phosphate rock for direct application and phosphate animal feeds. **h** Imported potash added to domestically produced nitrogen and phosphate to form multinutrient fertilizer. **i** Including resins for man-made fibers. **j** Estimated. **k** Data for noncellulosic fibers made of either synthetic or natural polymers (for example, based on casein or groundnuts); data exclude waste, glass fibers, and rubber fibers. **Source:** Central Intelligence Agency than official Soviet figures—7.8% in 1976 and 6.9% in 1977, for example—but CIA considers the Soviet figures to contain an upward bias.)

Development in 1979 is falling even farther behind target. Official Soviet figures show that overall industrial production through October grew only 3.6% (the goal for the year is 5.7%). Chemical industry output through September grew only 1% and was 5% short of the plan for nine months. And production through October of such key chemicals as fertilizers, plastics, synthetic fibers, and pesticides lagged behind even 1978 levels for the same period.

Chemical output is slated to rise 9% in 1980. However, Soviet planners already have signaled that the five-year plan goals for 1980 will not be met for most chemicals. For example, fertilizer production will reach only 98.3 million metric tons this year, barely more than last year's 98.0 million and far short of the goal of 111 million. The 1980 target is 115 million, up 17% from 1979 but 20% short of the five-year goal of 143 million.

Other East European countries show similar shortfalls. For instance, East Germany's five-year plan aims to increase overall industrial output 34 to 36%. The chemical industry is to grow much more, 44 to 46%. A rise in labor productivity (34 to 36%) is to account for much of the growth, a common objective in East Europe. However, CIA figures show an increase of only 11% in industrial production between 1975 and 1978.

Chemical industry output for the first half of 1979 also lagged behind target, according to East German statements. There were shortfalls for polyvinyl chloride (down 3.5% compared to the first half of 1978), and man-made fibers (down 2.3%).

Both Czechoslovakia and Hungary had mixed economic results in 1978, and have scaled back targets for this year and next. Czechoslovakia's chemical industry had better results last year than some other sectors, with output up 5.5%, according to official statistics. Polyethylene output grew 25%, polyvinyl chloride and copolymers 8%, and synthetic fibers 7%. The chemical industry led all Hungary's industries in growth last year, with production up 10.7%.

Bulgaria fell short of many plan targets last year. Chemical output grew 10% (the plan was 11.1%), with sulfuric acid production up 14%. However, fertilizer production dropped 1.6% below that for 1977.

Meanwhile, Romania—with the fastest growing economy in East Europe—fell short of targets in major areas last year, although still making considerable progress. Faced with growing manpower and energy constraints, it will have difficulty duplicating its double-digit industrial growth rates in the early 1970's. Industrial production rose 9% last year, according to official figures (6% by CIA estimates). However, the target was 10.6%. Chemical production—a top priority and slated for 160 to 180% growth in 1976–80—grew 10.1% but the target was 15.2%.

The 1979 plan still ambitiously calls for growth of 11.3% in industry overall and 18.3% in chemical production. And the next five-year plan (1981–85) targets an average annual growth rate of 9.0 to 9.8% for chemical industry (with plastics output up 50 to 70% between 1980 and 1985, synthetic fibers and yarns up 60 to 80%, and synthetic rubber up 40 to 60%). But Romania—an oil importer since 1976—is depleting its oil reserves.

Poland's economy is in the worst shape of all in East Europe. After dynamic growth in the early 1970's—running up large hard currency debts—Poland has had to curb growth, investment, and acquisition of foreign technology. Production of key chemicals lagged in 1978 (sulfuric acid up only 1.4% from 1977, fertilizers up 0.4%, and plastics up 1.7%).

Poland is focusing on consolidating and modernizing existing facilities, and trying to overcome structural problems similar to those plaguing all Soviet-bloc industry: inadequate transportation; insufficient fuels, energy, and raw materials; labor shortages; low productivity; poor product quality; poor industrial management; outmoded technology and equipment; and long delays in completing construction projects. ☐

Soviet chemical output seems sure to miss 1980 targets

Millions of metric tons unless otherwise noted	1979		1978		1977		1980
	Plan	10-month Result	Plan	Result	Plan	Result	original target^{a}
Mineral fertilizers^{b}	111	78.5	101.5	98.0	98.5	96.8	143
% increase^{c}	13.3%	−4%^{d}	4.9%	1.2%	6.7%	5.0%	9.8%^{e}
Synthetic resins & plastics	3.8+^{f}	2.9	3.6	3.5	3.4^{f}	3.3	5.4–6.0
% increase^{c}	8.6%^{f}	−1%^{d}	9.1%	6.1%	12.7%^{f}	7.9%	13.7–16.0%^{e}
Chemical fibers & yarns	1.20^{f}	0.91	1.14	1.13	1.10	1.09	1.45–1.50
% increase^{c}	4.6%^{f}	−2%^{d}	5.2%	4.0%	7.8%	6.7%	8.7–9.4%^{e}
Automotive tires^{g}	na	49.9	60.1	59.0	57.3	57.4	70–72
% increase^{c}	na	2%^{d}	4.7%	2.8%	5.1%	5.3%	6.2–7.0%^{e}
Pesticides & herbicides^{h}	na	401	na	492	489	487	615
% increase^{c}	na	−2%^{d}	na	1.0%	7.2%	6.8%	7.0%^{e}
Soda ash (100%)	na	na	na	4.9^{i}	5.1	4.9^{i}	na
% increase^{c}	na	na	na	−0.4%	6.2%	2.1%	na
Caustic soda (100%)	na	na	na	2.8	2.8	2.7	na
% increase^{c}	na	na	na	3.7%	7.7%	3.8%	na
Sulfuric acid (100%)	na	na	na	22.4	22.5	21.1	na
% increase^{c}	na	na	na	6.2%	12.5%	5.5%	na

a As planned at start of Five-Year Plan in 1976 **b** Conventional units **c** Increase or decrease from result in previous year **d** Increase or decrease from 10-month result in previous year **e** Calculated average annual increase required in 1976–80 to reach original 1980 target **f** Approximate **g** In millions of units **h** In thousands of metric tons **i** 1978 total of 4.858 million metric tons was actually lower than 1977 result of 4.876 million **na** = not available **Sources:** U.S. Department of Commerce and Department of State

China, overextended, sets new growth plans

Balanced, selective industrial development sought, top priority to synthetic fiber and fertilizer expansion

Richard J. Seltzer, C&EN Washington

China is continuing the economic and industrial growth—and the pragmatic overturning of previous economic and political taboos—that it began in 1977, following a decade filled with political and social upheaval that devastated its economy, science, and education. However, this year China found itself to be overextended, running head on into the structural limitations of its underdeveloped industrial and educational system. It therefore has scaled back and restructured its plans to enable slower, more balanced, and more selective development.

This "readjustment" policy will continue for three years, 1979–81, and lay the basis for more rapid growth under the next five-year plan (1981–85). The policy puts more emphasis on agriculture and on light and textile industry (producing for long-neglected consumer needs and for export) and relatively less emphasis on heavy industry. Within heavy industry, it stresses strengthening of "weak links" inhibiting all development—particularly coal, oil, electric power, transportation, communications, building materials, and nonferrous metals. And top priority goes to projects "that need less investment, produce quick returns, and earn more foreign exchange."

Moreover, the policy will push for thoroughgoing reform of industrial management, with stress on economic criteria, quality control, worker incentives and discipline, productivity, energy conservation, and training of management and workers. And there is a further looking outward—seeking compensation trade and foreign loans, and joint ventures.

China is now also more open about releasing economic data, for the first time since 1959—although still far from western practices. Official figures show that overall industrial production rose 14.3% in 1977 and 13.5% in 1978, both exceeding plan targets. In 1979, the readjusted goal is lower—just 8%, including 8.3% for light industry and 7.6% for heavy industry. After a slow start, the Chinese expect to meet these targets. Through October, production was 7.4% more than in the first 10 months of 1978.

Fibers lead rapid rise in China's chemical output

Thousands of metric tons	1978	1977	[illegible]
Chemical fertilizer[a]	8693	7236	[illegible]%
Sulfuric acid	6610	5375	23
Caustic soda	1640	1386	18
Soda ash	1329	1077	23
Plastics	679	524	30
Insecticides	533	457	17
Ethylene	380	303	26
Synthetic detergents	324	257	26
Chemical fibers	285	190	50
Pharmaceuticals	41	35	16

a On 100% effectiveness basis **Source:** State Statistical Bureau of People's Republic of China

Chemical industry priorities follow the national plan's emphasis on agriculture and textiles. Fertilizer production grew 66% between 1976 and 1978, to 8.69 million metric tons (on a 100% effectiveness basis). Output is slated to rise 10% this year, but production through October was already up 20% from the same period last year. Increased nitrogen fertilizer capacity is the main reason, as the 13 large ammonia-urea complexes purchased from abroad and small-scale plants have come on stream. However, large imports are still needed. Current plans are to build at least nine more ammonia units, each of 1000 metric-ton-per-day capacity, notes John C. Marshall of Contractors John Brown Ltd., London.

Meanwhile, synthetic fiber production is soaring, up 95% between 1976 and 1978. It is slated to rise only 5.3% this year, to 300,000 metric tons, but capacity under construction is expected to at least quadruple output.

The Chinese look to large imports of foreign technology and equipment as crucial for rapid expansion of their chemical industry, as well as other industries. Indeed, Marshall calls China "the last great market for the industrialized nations." However, by all accounts, the Chinese will build up production and reduce product imports as quickly as possible. And because of China's political and social system, western producers of consumer goods should base no dreams on its population of 1 billion.

China's total foreign trade last year jumped to $21.2 billion ($10.1 billion exports and $11.1 billion imports) from $15.1 billion in 1977. It is expected to reach $29 billion this year ($12 billion exports and $17 billion imports), according to U.S. Commerce Department estimates. About

85% of last year's trade was with noncommunist countries.

During the past eight years, China has bought nearly 150 chemical units, worth more than $4.8 billion, according to the National Council for U.S.-China Trade. China says it will spend $3 billion this year for technology and complete plants for chemical and other industries. And world sales to China of technology, equipment, and plants for all industries are projected at $40 billion between 1979 and 1985.

With political bars removed through diplomatic normalization early this year, U.S. trade with China in 1979 is expected to reach $2 billion, up from $1.1 billion in 1978. U.S. exports—mostly agricultural products—will make up $1.5 billion to $1.6 billion of this. This is still far below China's trade with Japan ($5.1 billion last year), and Japan is well positioned for further trade expansion. However, U.S.-China trade is expected to grow to $5 billion or more a year by 1985.

Of $1.26 billion in U.S. exports to China through October this year, $87.8 million worth was in chemicals. (There also were considerable chemical exports through foreign affiliates of U.S. firms, not included in U.S. figures.) Moreover, not counted in this "chemicals" category are such things as chemical technology and equipment, and large amounts of synthetic fibers—for example, $47.1 million of polyester fiber (noncontinuous form) through October.

U.S. chemical exports to China have expanded very rapidly. The $87.8 million for the first 10 months of this year is almost double the $46.4 million exported during the like period of 1978. The U.S. sold China $60 million worth of chemicals in all 1978, $20 million in 1977, and $10 million in 1976. The National Council for U.S.-China Trade projects annual U.S. chemical exports and imports of $350 million each by 1985.

Agricultural chemicals—particularly nitrogen fertilizers and insecticides—and resins top the U.S. export list. For example, $20.7 million worth of urea, $18.2 million of polyester resin, and $4.9 million of organophosphorus insecticides were sold in the first 10 months of 1979.

U.S. chemical imports from China totaled $44.9 million in the 10 months through October 1979 (up from $26.1 million in the same period a year ago), out of total U.S. imports from China of $458.5 million. This includes $6.8 million worth of menthol and $13.3 million of fireworks. Indeed, fireworks, categorized as a "chemical," is currently the second highest U.S. import from China, exceeded only by crude petroleum ($55.7 million).

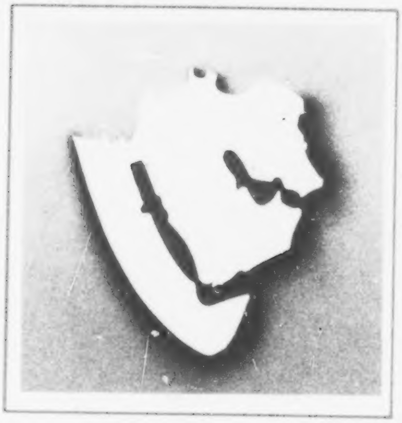
Congress is expected to approve soon a U.S.-China trade agreement extending most-favored-nation tariff treatment to China and providing for some patent and copyright protection (no full protection as yet in China). Most-favored-nation status will reduce some chemical tariffs. For example, the tariff on pharmaceuticals will drop from 10% to 1.5%, and on menthol from 50 cents a lb to 17 cents. However, Commerce Department analysts do not expect this to have much impact on Chinese chemical sales, because Chinese prices are already competitive.

Nevertheless, large imports from China already have caused problems for U.S. textile producers, and the U.S. has imposed quotas unilaterally after failing to reach agreement with the Chinese. Menthol imports are also worrying U.S. producers (some firms are talking about possible "dumping" charges). And a Commerce Department list cites other chemicals that China exports whose U.S. producers might be affected by increased imports: benzenoid drugs, aromatic compounds, sodium acetate, camphor, carbonates, borates, sulfates, and antimony oxide. □

Chinese chemical capacity will soar over next few years

Thousands of metric tons	1978	Planned[a]
PETROCHEMICALS		
Ethylene	490	2110 + 115?[b]
Low-density polyethylene	240	300 + 280?[b]
High-density polyethylene	35	455
Vinyl chloride	na	400
Polyvinyl chloride	40	480
Ethylene glycol	60	60
Acetaldehyde	30	180
Ethanol	na	200+
Methanol	na	100
Polypropylene	115	115
Butadiene	45	120
Aromatics	na	600
Phenol	na	50
Oxo alcohols	na	140
Methylenediphenyl isocyanate	na	10
Epichlorhydrin	na	55
FIBERS AND INTERMEDIATES[c]		
Acrylonitrile	75	75
Acrylic fiber	35	35
Nylon 66	50	65
***p*-Xylene**	64	na
Terephthalic acid	na	475
Dimethyl terephthalate	90	90
Polyester chip	130	860
Polyester fiber	180	180+[c]
FERTILIZERS		
Ammonia (as product)	4620[d]	6270 + 990?[b]
Urea (as product)	7050[d]	7620 + 560?[b]
Phosphates (as P_2O_5)	1500–2000	2500[e]
Potash (as K_2O)	300–350	500[e]

a Estimated by summing current capacity, capacity now under construction, and apparently firm announcements of construction plans. **b** Question mark indicates capacity possibly planned, rather than firmly committed. **c** Figures are believed to understate current and future fiber capacities, especially future polyester fiber capacity. **d** Includes only 13 large ammonia-urea complexes purchased from abroad; excludes smaller plants. **e** By 1980. **na** = not available. **Source:** John C. Marshall, Constructors John Brown Ltd.



Middle East lays a petrochemical groundwork

Cost of building plants in the Middle East is high, and their impact on world markets is still far from clear

Dermot A. O'Sullivan, C&EN London

The Middle East appears set to become a major source of petrochemicals in the coming decade. Opinions differ, however, about the magnitude of the effect on established producers in Western Europe and elsewhere.

"The increasing involvement of the Middle East in the European petrochemical scene is likely to be one of the most significant happenings of the next decade," observes Stuart H. Wamsley, chemical industry marketing analyst with Hedderwick Stirling Grumbar in London. "With European growth rates likely to be on the low side, it will be up to western and Middle Eastern producers to take all possible steps to ensure that common sense prevails."

On the other hand, Tony Church of Kidder Peabody's London office states, "In our opinion, Middle East exports, once they begin to arrive in West Europe, will not cause massive disruption. We believe that the Middle East threat will materialize only over a much longer term and even then will be less severe than expected, provided West European attitudes soften and the Middle East position does not harden."

Notes Anthony Lowe, head of planning and economics at Shell International Chemical, "Having regard to the difficulties of construction in many oil-producing countries, many feel that [they] would do well to achieve 5% of world petrochemical production by 1990. The growth of the share of the world industry held by oil-producing countries will increase steadily in the next few years. But it will take longer to reach its ultimate share than was originally thought possible."

Chemical manufacturing is not new to the Middle East. Israel, for instance, already has a highly sophisticated and diverse chemical industry. A number of the countries have been making inorganic chemicals, as well as nitrogen fertilizers from natural gas, for some time. What has caught the attention of the West has been the widely proclaimed intentions of some countries to make a variety of petrochemical intermediates and downstream derivatives.

In the case of Qatar, these plans already have taken concrete shape. Qatar General Petroleum Corp., in partnership with CdF Chimie of France, is well along in putting up a cracker at Umm Said. Qatar Petrochemical Corp. (Qapco), the name of the venture, will use ethane separated from Qatar's plentiful supplies of natural gas liquids as feedstock. Ethylene will go to make low-density polyethylene. Both units are scheduled to start up late next year.

The cracker will be able to make 616 million lb of ethylene annually. This will be more than enough to supply the 308 million lb-per-year LDPE unit, which is expected to reach full capacity in 1982. Studies are under way on various options to utilize the uncommitted ethylene in a profitable manner, Qapco says. Meanwhile, CdF Chimie, which is providing process know-how for both plants and is training people to operate them, will market the LDPE through its existing sales outlets.

Perhaps taking a leaf out of Qatar's book, Saudi Arabia, too, is aiming to get into petrochemicals with outside partners, though on a very much larger scale. Agreements on two projects already have been signed. Discussions still are under way on projects involving Celanese and Texas Eastern, Dow Chemical, Exxon, Mobil, Shell Oil, and a group of Japanese companies. All but one of the operations are slated to go in at Al-Jubail, on the Persian Gulf.

During the past month, Saudi Basic Industries Corp. (SABIC) signed an agreement with a group of Japanese companies comprising C. Ito, Mitsubishi Gas, and others to build a 1.3 billion lb-per-year methanol plant. And with Taiwan Fertilizer Co., state-owned SABIC will put up a 1.1 billion lb-per-year urea plant. Both are expected to be ready for operation by 1984.

According to Abdullah S. Nojaidi, SABIC's marketing manager, talks are well along with the other companies. He expects the first contracts to be signed early next year.

Methane and ethane will be separated from the country's oil-well gas. The methane will be used to make methanol and urea, the ethane will go to the crackers. As plans now stand, some ethane will be piped the 700 miles or so west to Yanbu, where it will feed a cracker Mobil is contemplating next to a projected 250,000 bbl-per-day refinery it may build with Petromin, the Saudi state-owned oil and minerals organization.

Nojaidi says the partners in the various schemes will take the bulk of the products and channel them into the world market. He also appears confident that all of the projects will be operating before 1984.

This seems overoptimistic, since final commitments for most of them haven't been made formally. Moreover, building such complex plants involving, highly sophisticated equipment and instrumentation, won't be easy in view of Saudi Arabia's severe climate and generally poor infrastructure system. These problems may be partly circumvented by prefabricating sectional units of the plants elsewhere.

The cost, obviously, will be considerable, more than it would be to build the plants in Europe or the U.S. At a Society of Chemical Industry meeting in London last month, Len R. Burchell, BP Chemicals' managing director, provided some rough estimates of what the cost differential might be.

In Western Europe, a 1.1 billion lb-per-year (of ethylene) cracker, together with plants for making the usual range of downstream products, would cost about $2.6 billion, he says. This would include $1.5 billion for materials and $900 million for labor. For a similar complex in the Middle East, according to Burchell, the figure would be closer to $4 billion—$2 billion for materials and between $1.5 billion and $1.9 billion for labor. Somewhat offsetting the differential, of course, is low-cost feedstock.

"Another factor weighing against Middle East production is the cost of bringing material to Europe," Burchell adds. "Building a plant in the Middle East rather than in Europe will be justified if the cost differential between transporting gas to Europe on the one hand, and transporting products on the other, is more important than the differential in construction costs in the two areas." Burchell hastens to add that these are generalized conclusions.

Saudi Arabia has ambitious petrochemical plans

Capacity, millions of lb per year	Foreign partners						
	Dow Chemical	Mobil	Shell Oil	Exxon	Celanese/ Texas Eastern	Various Japanese partners	Taiwan Fertilizer
Ethylene	1100	990	1443	—	—	990^a	—
Ethylene dichloride	—	—	999	—	—	—	—
Ethylene glycol	660	440	—	—	—	—	—
Ethanol	—	—	618	—	—	—	—
Polyethylene, low-density	154	440	—	528	—	—	—
Polyethylene, high-density	231	200	—	—	—	—	—
Methanol	—	—	—	—	1540	1320^b	—
Styrene	—	—	649	—	—	—	—
Urea	—	—	—	—	—	—	1100
Sodium hydroxide	—	—	829	—	—	—	—

a Mitsubishi Chemical, Mitsubishi Petrochemical, and others. **b** C. Ito, Mitsubishi Gas, and others. **Note:** All of these proposed projects will be in partnership with Saudi Basic Industries Corp. **Source:** Saudi Basic Industries Corp.

In Iraq, Lummus is building a complex that is expected to be ready next year. The 308 million lb per year of ethylene potentially available will be used to make low- and high-density polyethylene and polyvinyl chloride.

In Kuwait, state-owned Petrochemical Industries Co. has completed feasibility studies that, the company expects, will lead to two complexes by 1985. One will be centered on 770 million lb per year of ethane-derived ethylene. This will go to make LDPE (286 million lb-per-year capacity), glycol (297 million lb per year), and styrene (715 million lb per year). An aromatics complex should be capable of producing 625 million lb of benzene, 132 million lb of *o*-xylene, and 189 million lb of *p*-xylene yearly.

A nagging worry in the back of most people's minds right now is concern about the future political stability of the Middle East.

B. F. Goodrich was one of the first companies to suffer. Abadan Petrochemical Co., a joint venture of Goodrich and Iranian National Petrochemical Co., was nationalized. The operation makes raw materials for detergents and plastics.

Du Pont, too, has been hard hit. Polyacryl Iran Corp. (PIC) closed its plant at Isfahan late last year, within months of startup. The company, in which Du Pont has a 40% stake with private Iranian interests owning the balance, had an annual capacity of 40 million lb of acrylic fibers and 60 million lb of polyester fibers.

In response to a Du Pont petition, U.S. District Court judge Richard Owen late last month issued an order of attachment against the state of Iran and PIC for $93 million. The sum includes $62.8 million in loss of equity and reasonable return, according to Du Pont, and $10 million in loss of anticipated dividends.

Nor can the Japanese be happy with their Iranian experience. The biggest project, and the one in most serious financial trouble, is that of Iran-Japan Petrochemical Co. It is a joint venture between Iranian National Petrochemical and a group of Japanese companies, the largest share belonging to Mitsui.

At Bandar Khomeini (formerly Bandar Shapur), Iran-Japan Petrochemical is putting up a major complex based on a naphtha cracker with a design capacity of 660 million lb of ethylene per year. A host of downstream product units are part of the scheme. The project is far from finished, although it had been expected to be ready this year. It will take a lot more money on top of the many millions already spent there to see it through. □

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Gains in 1970's came the hard way

For U.S. chemical industry, the seventies couldn't match sixties for growth in jobs and output, but profitability firmed, foreign trade soared

William F. Fallwell
C&EN, New York

The 1970's won't soon become a mine for nostalgia buffs, who right now are dwelling on almost any other period.

A hard-nosed reversal of the 1960's, the seventies brought roller-coaster economic cycles and pruned the rewards mainly to those of discipline and, at times, a bit of luck. Fortunately, the U.S. chemicals and allied products industry got at least its share of the latter, according to C&EN surveys of vital economic indicators over the past 20 years.

Although the seventies had their grinding aspects for U.S. chemicals, the decade finished better than it began in some important respects, notably in profits, plant use, and foreign trade. These improvements promise some good years in the early 1980's after a likely pause for recession in 1980 itself.

It all depends on one's point of view. On the people front, the chemical industry hardly expanded at all in the 1970's except in special categories of women, minorities, and scientific and technical professionals. However, even for women and research and development professionals, employment growth ran at just half its rate for the previous decade.

For plant personnel, who hold nearly three of every five jobs in the chemical industry, the 1970's saw virtually no employment growth. Since the workweek was also stationary, these employees had to become more efficient. This shows up in a rate of productivity gain surprisingly close to gains in the 1960's. However, wages really took off in the 1970's, resulting in steadily increasing unit labor costs compared to the declines of the previous decade.

On the product front, the 1970's, as expected, trimmed the rate of output growth in nearly every major category. The decade also brought a stern downward adjustment in development of new products and processes in favor of an intense campaign refitting present products and processes for greater safety, less pollution, and energy savings.

Even so, some products grew surprisingly well in the seventies. The star of the decade indisputably was plastics. Despite the Organization of Petroleum Exporting Countries, U.S. government regulation, and an image problem, plastics grew nearly as fast as they did in the sixties.

With moderate growth generally in its products, no growth in employment, and a strong efficiency drive in many directions, the chemical industry certainly stood a basic chance of improving its financial performance. And that's exactly what happened, although some stiff challenges made the outcome uncertain at times. The worst challenge was drastic increases in the cost of everything, including money.

The chemical industry had come through the sixties with a tradition of absorbing higher costs through efficiency gains. In fact, companies steadily lowered product prices. The raging inflation of the 1970's put this tradition to an impossible test. However, the chemical industry managed to swallow the cost bulge without hurting profitability by increasing product prices about in line with general inflation.

As a result, the industry ended the steady erosion in profitability from the 1960's. In the seventies, profits

Growth in the 1970's was less than in 1960's except in inflated money figures, foreign trade

U.S. chemicals and allied products	Annual averages			Average annual change, %	
	1979	1969	1959	1970-79	1960-69
PEOPLE					
Employment, thousands					
Total	1112	1060	809	0.5%	3%
Production employees	637	622	506	0.2	2
Women	270	220	151	2	4
R&D professionals	49	40	32	2	4
For production employees					
Hourly wage	$7.56	$3.47	$2.40	8	4
Workweek, hours	41.8	41.8	41.4	0	0.1
Total weekly workhours index (1967 = 100)	108.2	105.5	84.9	0.2	2
Productivity index (1967 = 100)	194.5	112.2	64.0	6	6
Unit labor costs index (1967 = 100)	125.4	99.7	120.9	2	−2
PRODUCTS (indexes, 1967 = 100)					
Chemicals & allied products	210.5	118.4	54.3	6	8
Basic chemicals	189.9	117.0	58.0	5	7
Alkalies, chlorine	129.8	115.1	76.1	1	4
Organics	231.2	125.3	48.8	6	10
Inorganics	133.1	97.6	70.4	3	3
Synthetics (polymers)	319.9	141.2	43.5	9	12
Plastics	416.7	148.6	46.7	11	12
Rubber	131.3	117.7	74.0	1	5
Fibers	271.0	139.8	36.1	7	14
MONEY, $ billions					
Sales (worldwide)	$170	$ 56	$ 26	12	8
Profits	$11.3	$3.6	$ 2.1	12	6
Profit margin on sales	6.6%	6.4%	8.1%	—	—
Product price index (1967 = 100)	222	100	102	8	−0.2
Capital spending	$8.5	$3.1	$ 1.2	11	10
R&D spending	$3.9	$1.7	$ 0.8	9	8
Foreign trade					
Exports	$17.0	$3.4	$1.6	17	8
Imports	$7.3	$1.2	$0.5	20	9

Sources: Commerce Department, Labor Department, Federal Reserve Board, Federal Trade Commission, National Science Foundation, C&EN calculations and estimates grew about in line with sales. One help was a rate of real-dollar new plant investment much lower than in the 1960's. This brought plant use into a more desirable range as the 1970's closed. A second big help was a boom in foreign trade greatly favoring U.S. exports. The U.S. finished the decade as the most attractive area of the world for making chemicals.

All in all, the seventies may have come out well in the end for the chemical industry. But this kind of progress was a far cry from the growth-oriented smooth sailing of most of the sixties. In a way, the seventies brought the industry to grips with a number of basic problems that could not be ignored under tougher economic and regulatory circumstances.

Statistics from various government sources show how the chemical industry tightened up in response to a stormier business climate, and the heavier hand from Washington. The biggest change in the growth of its resources was in people. From an average 3% gain per year in the 1960's, chemical employment slowed to a 0.5% average increase in the 1970's, winding up at 1.11 million in 1979 compared to 1.06 million in 1969. For production employees, the drop was from 2% per year to 0.2%, leaving their ranks at 637,000 in 1979 after 622,000 in 1969.

Smaller groups fared better. Chemical employment for women grew 2% per year in the 1970's compared to 4% in the 1960's. But since total employment hardly budged, women increased their part of the total to 24% in 1979 from 21% in 1969 and 19% in 1959.

For scientists and engineers in R&D, jobs (in terms of full-time equivalents) grew 2% per year in the 1970's after 4% in the 1960's in chemicals and allied products. These employees numbered about 49,000 in 1979, C&EN estimates, compared to 40,000 in 1969 and 32,000 in 1959. Hence, their part of the total chemical workforce picked up to 4.4% in 1979 from 3.8% in 1969 and 4.0% in 1959. The gains in the 1970's came more in the second half than in the first few years and continue rather well at present.

Since these professionals' salaries take up about half of R&D support at chemicals and allied products companies, R&D budgets had to grow substantially in the 1970's. C&EN estimates companies' R&D spending in 1979 at $3.9 billion, more than double spending of $1.7 billion in 1969 and nearly five times spending of $800 million in 1959. Average annual budget growth in the 1970's was 9% after 8% in the 1960's. With inflation removed, this growth left a small margin of real-dollar gains, about 1 to 2% per year in the 1970's. As in past C&EN surveys, this real-dollar growth corresponds closely with growth in employment for R&D professionals.

Even this modest increase in jobs looks like a lot compared to the employment at chemical plants. One major disincentive was the big increase in labor costs unmatched by productivity gains. In this respect, the seventies were the reverse of the sixties. Although productivity (physical output per workhour) gains averaged 6% per year in both decades, hourly wages shot up 8% per year in the seventies following 4% in the sixties. Hence, unit labor costs (cost per unit output) rose 2% per year in the 1970's after falling 2% per year in the 1960's.

Another reason plant employment idled in the 1970's was that production and real-dollar new-plant investment both toned down from the 1960's. For the broad chemical industry, production rose 6% per year in the more recent decade compared to 8% in the sixties.

In basic chemicals, growth was 5% per year in the 1970's compared to 7% in the 1960's. The only reason growth held up even this well was a 6% annual clip in output gains for organics in the 1970's. Alkalies and chlorine sank to a 1% annual gain, and inorganics plodded along at an annual rate of 3%.

The best source of growth for chemicals in the 1970's was through downstream polymers, especially plastics. Polymers as a whole grew 9% per year in the 1970's compared to 12% in the 1960's. However, plastics nearly equaled their decade-earlier growth, down just one percentage point to 11% per year in the 1970's. Fibers' growth rate fell by half in the 1970's to 7% per year. For rubber, the seventies were a rough time, with growth just 1% per year after 5% in the sixties.

Chemical companies adjusted their plant investment quite well in line with the reduced rate of product growth. Official capital spending budgets rose 11% per year in the 1970's after 10% in the 1960's. However, inflation reduced average real-dollar growth in new plant and equipment to 3% per year at the most in the 1970's. And actual net increases in new production capacity were probably less than that because of a widespread tendency to use more capital funds for refitting old plants than in new construction.

As a result, plant efficiency and use rates today are much better generally than in 1969. Although the next decade may well start with a recession as did the 1970's, the chemical industry may not have to wade through a soft market spell for as long as it did 10 years ago.

Chemical profits are showing the effects of better plant use. For the 1970's, after-tax profits in chemicals and allied products rose an average of 12% per year, reaching $11.3 billion in 1979 after $3.6 billion in 1969 and $2.1 billion in 1959. Although annual profits growth was just 6% in the 1960's, the difference in the growth rates is due almost entirely to inflation. Real-dollar profits growth in both decades was about 4%.

Profits growth in the seventies caught up with sales growth, which also averaged 12% per year. Sales had climbed a vigorous 8% per year in the less inflationary sixties, well ahead of the profits pace. Hence, the profit margins on sales in chemicals and allied products edged up a bit in the seventies, ending with about 6.6% in 1979 compared to 6.4% in 1969.

Although the chemical industry can trace much of its profits firming in the seventies to bootstrap efforts in efficiency, the industry also got a major lucky break in foreign trade, and from a surprising source. Although the industry at the time had great misgivings about OPEC's dramatic increase in the oil price in 1973, the new price structure for world hydrocarbons turned out to be a bonanza for U.S. chemicals. Since imported oil accounted for only a quarter of the industry's feedstock and energy costs as late as 1978, the industry was much more shielded in such cost increases than were competing industries in Europe and Japan.

As a result, U.S. foreign trade in chemicals mushroomed in the late 1970's, reaching an estimated $17 billion in exports and $7.3 billion in imports in 1979. These figures are up a resounding 17% per year in exports and 20% in imports from 1969. In the sixties, the corresponding growth rates were 8% and 9%. By 1979 U.S. chemical exports accounted for 10% of total sales, up from 6% in 1969 and 1959.

Although this trade advantage is not expected to last indefinitely, the U.S. chemical industry is still under stronger control now than in 1970. In 1970, no one suspected the degree of disciplining about to hit the industry after its heady expansion days. In 1980, some in the industry are contemplating what might happen if the stringent conditions of the decade just ended eased even slightly in the years ahead. Even if strictures continue, the general feeling now is, "We're ready." □

News Feature

White House innovation plan off and running

Called meager by critics, Administration's technology policy spans several agencies, integrates programs; more legislation and newer policies planned, but does new program meet today's realities?

Wil Lepkowski
C&EN, Washington

Everyone who followed the Carter Administration's 18-month Domestic Policy Review on technological innovation knows that Uncle Sam declined to bring industry the gifts it most wanted.

Indeed, as one official in the Office of Management & Budget put it to C&EN, the President opened up his technology policy bag and out ran a mouse. The consensus around Washington has been that the "initiatives" were philosophically and fiscally pale—in fact, minor.

"The Administration," said former assistant Commerce Secretary Betsy Ancker-Johnson to a Senate hearing in November, "has thoroughly discredited itself as a leader in the development of technology policy." Now vice president for environmental activities at General Motors, Ancker-Johnson says that Carter failed to deliver on the issues that mattered most to big and small business—reform of antitrust policy to make joint ventures easier, restructuring tax policy to loosen investment capital, and redesigning regulatory policy so industry can spend more time doing research and development instead of paying excessive compliance costs.

On regulatory policy, Ancker-Johnson wasn't quite right, but she can hardly be blamed for chomping at the bit. When she was assistant secretary for science and technology four years ago, she put together a framework for technology policy, and her successor, Jordan J. Baruch, proceeded to act as if it had never been done.

But successive Administrations often act that way, especially if the political parties differ.

Nevertheless, the severest of the critics say that Frank Press, White House Science Adviser, and Baruch wasted valuable time. They believe that Baruch, whose assistants Theodore Schell and Frank Wolek ran the review, focused on making his own unique contribution rather than on the work of simply delivering a synthesis of studies done before, plus an agenda for a Presidential action program.

Thus, these critics say, the review revealed nothing new, and even the claim that the national consciousness was raised over the importance of the issue held only drops of water. Indeed, the backing of the Chrysler loan by the Administration was testimony enough that noninnovative, poorly productive companies, when big enough, will be propped up and bailed out when about to die a natural death. Some critics wonder whether Carter was listening to his own science and technology message.

Furthermore, the critics say, Press and Baruch failed to put the issue of innovation in a global and strategic perspective. They feel the program should have been more dramatically tied to an articulation of problems facing the country in the 1980's—trade crises, fuel shortages, raw materials scarcity, financial and monetary stresses affecting technological and raw materials investments, capital shortfalls, and increasing social malaise. Innovation for an economic system undergoing basic structural change, they say, was the kind of message the more thoughtful were waiting for. But they didn't get it and they felt cheated.

But the facts are that the Domestic Policy Staff, which is to say Stuart Eizenstat, didn't really want anything too broad or too fiscal. It wanted a limited debate. It ranged across agency programs but it was in reality a study along a narrow waveband, narrowed even further by leaving out important policy options.

Vanik: no incentives that will work

The gaps led Rep. Charles A. Vanik (D.-Ohio) to comment: "The Administration plan gives no incentives that are going to work. I'm concerned about our tremendous erosion of our technological base. In the 1980's technological leadership will be essential for survival on all fronts, domestic and foreign."

Vanik is the third-ranking member of the House Ways & Means Committee, where all tax legislation begins. He appears to have gotten innovation fever and is sponsoring a bill, H.R. 5881, that would establish tax credits on portions of an industrial fund that would go to research and development in universities. His bill is one of several innovation bills floating around Capitol Hill.

"The whole [Domestic Policy Review] thing was overblown," says a staffer at the office of Management & Budget. "We just didn't have a hell of a lot to offer these people. We all know Charlie Schultze [chairman of the Council of Economic Advisors] has been concerned a long time about making tradeoffs between environmental regulation and economic

The Administration's technological innovation effort has 15 major programs

Program	Center for Utilizing Federal Technology	Foreign technology utilization	Generic technology centers	Regulatory technology development	Better industry-university cooperation in R&D	Uniform government patent policy	Upgrading of Patent & Trademark Office
Agency	National Technical Information Service, Department of Commerce	NTIS	Department of Commerce (three centers); National Science Foundation (one center)	Office of Management & Budget, overseeing regulatory agencies or Productivity Council	National Science Foundation	Office of Science & Technology Policy	Patent & Trademark Office
Contact	Melvin Day (703) 557-4636	Melvin Day (703) 557-4636	Commerce: Francis W. Wolek (202) 377-3966; NSF: Robert Colton (202) 634-6204	Undecided but try Phillip Smith, OSTP, (202) 395-6244	Robert Colton (202) 634-6204	Phillip Smith (202) 395-6244	Patent Commissioner Sidney A. Diamond (703) 557-3071
Purpose	New, improved ways of informing industry of inventions in federal laboratories	Collect and disseminate information on foreign, potentially innovative technologies	Industry/government-funded centers to upgrade broad, basic technologies	Improve innovation in regulatory compliance technology	Help universities understand style and scope of industrial research, train students better for careers in industry	Give companies exclusive licenses to develop government-owned inventions. Would be governmentwide policy	Further automation of filing, classification; establishment of single count only for patent appeals; re-examination of issued patents on request
Fiscal 1981 funding	$1.2 million	$4.2 million	$6 million to $8 million	—	$20 million	—	Not determined
Comment	NTIS will hire several writers and analysts to produce interpretive material. Effective implementation, extension, could cost much more than proposed $1.2 million	Translations of foreign literature ($1.8 million). Funding probably insufficient. Part two ($2.4 million) involves federal debriefing of visitors to foreign countries. Could take years to produce relevant information	Generic technologies include welding, corrosion prevention, lubrication. NSF supports several such centers and reports success. A favorite scheme of Jordan Baruch	Most agencies (OSHA, FDA, EPA) have long been made conscious of promoting best and most efficient technology. Big need is experienced staff of agencies	Said to be one of best-run NSF programs. Plans to extend program to other agencies with goal of $150 million total	A long-sought program often thwarted by public interest groups and populist politicians. Outlook fair, but opposition will fight. Will require legislation	Chances good. Senate and House behind proposals. Legislation already introduced in Senate

growth. We're already doing something about that. Taxes we couldn't do anything about because the Administration didn't want innovation to get mixed too heavily too early with next year's tax package."

It is generally felt that Baruch did not get all he wanted after his document went up to the White House Domestic Policy Staff last summer. Al Stern, the Domestic Policy staff aide in charge of administering the review, says Baruch initially wanted some commitments at least to altering tax policy for releasing a flow of funds that presumably would go to innovation. But DPS wanted a narrower focus, Stern tells C&EN, fearing that any commitment to tax policies would branch out into fields outside innovation.

"We just don't think tax measures are a major stimulant to innovative activity at this junction," he says. "We think there's going to be a downturn, we don't know when, and we certainly don't feel we want to accelerate the inflation problem."

There is the possibility, Stern believes, that much of the innovation lag industry complains about may be self-induced, too. "Industry has a great deal of conservatism in its own house," he says. "There's a large amount of restraint on the management side, and that could depress innovative activity. When I hear industry complain about our lack of action, I simply tell them to go out and innovate."

Stern says that when one tries to discover whether there actually has been a dropoff in American industry's ability to innovate, then the measurements become less convincing. This makes the steps, even to the policy's architects, more than a little dubious.

"I have no doubt that accelerated depreciation would have an impact on innovation," Stern says. "But it would have much larger consequences elsewhere. The reasons for accelerating depreciation have to do with much more than innovation. We want to make sure there are no negative impacts elsewhere. We looked at venture capital. And the early returns tell us that venture capital is more plentiful than ever. But it seems to be high only for second stage financing. Seed money is hard to come by. 'Petromoney' isn't used for venture capital because it seems the more there is of it, the less it is used for risky ventures. So the question came down to finding some mechanism for producing seed money for initial financing without making government finance every scheme in the world."

Much of the final Presidential wording was chiseled out by Stern and by Philip Smith, a top aide to Frank Press. Smith, quite naturally, is enthusiastic about the product. He

Office of Small Business Patent Counsel	Clarifying antitrust policy	Small business innovation research program	Corporations for Innovation Development	Federal support for small R&D businesses	Venture capital availability	Opening federal procurement to innovations	Improving government regulations
Small Business Administration	Justice Department, Federal Trade Commission, OSTP	National Science Foundation	Department of Commerce (some NSF help)	Small Business Administration	Small Business Administration	Office of Management & Budget, General Services Administration	Environmental Protection Agency, Food & Drug Administration, Occupational Safety & Health Administration
Milton Stewart (202) 653-6533	Justice: Ky Ewing (202) 633-2562, FTC: Robert Reich (202) 523-1447, OSTP: Phillip Smith (202) 395-6244	Roland Tibbetts (202) 634-6204	Philip Goodman (202) 377-3914	Milton Stewart (202) 653-6533	Milton Stewart (202) 653-6533	OMB: Fred Dietrich (202) 395-6810 GSA: Gerald McBride (202) 566-1043	Call Phillip Smith at OSTP for referral (202) 395-6244
Help inventors convert activities to small businesses by entrepreneurial counseling	Explain antitrust policy to industry more systematically; publish guidebook on antitrust/innovation for industry	NSF provides venture analysis and feasibility testing support to new firms	Help states give support to new businesses	Give small R&D firms bigger slice of federal grant and contract business	Changes in Small Business Investment Corporations/Employment Retirement Security Act policies	Policy changes to ease entry of innovative products into government purchases. Small business will be given preference	Substitution of performance for design standards; five-year forecasts of priorities. Clearance based on innovativeness of product
Negligible	Negligible	$10 million above current $2.5 million	$8 million ($4 million per center)	Negligible	—	—	—
Universal approval	Industry chronically complains that antitrust policies are vague and inconsistent on joint ventures. Wants more flexibility. Justice says it is flexible enough. No policy changes expected	Goal to establish same program in other agencies to goal of $150 million total funding	Legacy of old, defunct State Technical Services Act. Some state programs good, some not so good. British model experience mixed, since British innovation record poor of late	OMB will monitor progress. Will require vigor and verve by Stewart, or whole thrust could be forgotten. Small business groups will need to maintain pressure	Possibly significant. ERISA change was recommended by several industry panels. Much depends on decisions by pension fund managers	Experimental Technology Incentives Program in National Bureau of Standards paved way for this program. Was product of Nixon science and technology message of 1972	Further steps in Administration policy for cutting regulatory red tape, giving industry better means of anticipating regulatory policies, actions

says implementation of even this first step will take two or three years but that the initiative is integrated and long lasting.

Right now, he says, the most spirited activity is around the structure of the bill needed to modernize the patent office.

"For example," Smith says, "we're aware of the inequities of the patent system for chemical and pharmaceutical companies where regulatory compliance holds back the introduction of a new product many years. The patent life by the time the product is introduced is half exhausted, thus reducing the profit rewards the company would get for disclosure of the invention.

"We may come to the point of proposing extension of the patent life," he says, "but we're not at that point yet. Other things need to be done first. An even more fundamental issue is developing legislation to extend the patent system to developments in the life sciences and to computer communication systems."

In six months Baruch is scheduled to deliver to the Domestic Policy Staff a progress report on each of the programs proposed by the President. Meanwhile, technology policy framers in Commerce, the Office of Science & Technology Policy, and DPR will be stepping up what already will be going on.

"We intend to enlarge the generic technology area, provided the four experiments we are proposing don't fall flat," says Stern. "We will look further at the research and development interplay between industry and universities. We'll also be doing work on the tax front, with the good possibility that innovation will claim a whole section of the Administration's omnibus tax bill. We also will want to look at whether there is a regional falloff in innovation patterns, such as between New England and the Sun Belt states. We'll be looking further into the international flow of innovation."

Other possibilities could include a sweeping assessment of innovation needs in what the Administration euphemistically calls a "constraint economy," which means serious recession or depression. "Commerce should be the agency examining that," Stern says. A National Technology Institute along the lines proposed in Sen. Adlai E. Stevenson's (D.-Ill.) innovation bill, S. 1250, is remote but still a possibility. But Stern says that while Stevenson's bill would establish a big overall technological institute, the Administration might tend to envisage institutes of a much narrower focus, such as development of engineering manpower for national needs and technological goals.

The subject is almost too complex

to handle piecemeal much less in an integrated way because of the way innovation covers all aspects of an industrial economy. For example, OMB is nowhere clear on the right type of balance that should exist between federal and private sector funding of new technologies. Some OMB elements doubt whether the government should be involved in any development projects.

"We are now experiencing growing cynicism about the contribution of federal research and development to the economy," says an OMB manager. "By that I mean the idea that if we only tried harder government R&D would solve our problems. We're also again feeling that what we are spending in energy the private sector after all should do by itself. It's hard to know the difference between money for demonstrations and outright subsidies."

It is clear, then, that the debate over innovation will sizzle through the turbulent eighties. Groups at such far poles as the American Enterprise Institute, which speaks for a conservative capitalism championed by Ronald Reagan and John Connally, and the Center for Economic Alternatives, which wants an economy more geared to meeting the needs of the common man, are both developing programs on the subject.

One figure who hasn't been officially heard from in some time is Commerce Department senior economist Michael Boretsky. It was Boretsky who sparked the debate over America's technological competitiveness during the early 1970's, when previous Commerce Secretaries were proposing to then President Nixon a program not far removed from what Carter announced last Oct. 31.

Though ignored by Baruch, Boretsky continues to assemble data and analyses on such matters as productivity, technological economics, and inflation. He is especially concerned about the strategic consequences of a continued U.S. decline in international technology markets and delivered his perceptions on the subject in a speech last year to the Army War College. At the moment, Boretsky's views are not popular among Administration economic policymakers because he believes that U.S. corporations, through their export of technology abroad, are contributing to the erosion of the country's balance of trade and overall strategic balance in the all-important high technology industries.

Transfers of technology—either through the multinationals or through licensing to foreign firms—have a detrimental impact on national security, he says. The net impact, he says, "is adverse effect on the balance of payments and external value of the dollar. This, in turn, affects the country's economic, political, and military posture abroad, including the many strictly defense-oriented installations which the nation maintains overseas," he told his military audience.

Boretsky believes the decline in the country's technological competitiveness contributed to the 1971–73 dollar devaluation "much more than all other factors combined."

He adds, in fact, that "based on my calculations and analysis, I came to a firm belief that had the U.S. done nothing more than it has actually done in promoting new technology at home, but had fostered exports of its products with the same vigor as it fostered export of licensing technology, the kind of deterioration of U.S. trade and balance of payments that we have been witnessing since 1971 might have come eventually, perhaps in the twenty-first century. But not in 1971."

His views are those of Boretsky, the individual, rather than as policy analyst for the government. But they are well-known throughout the Washington technology policy community. He wants Washington's current technology establishment to make an objective assessment of the national security implications of "either the transfers of technology or the emergence and growth of the Eurodollar markets."

Boretsky's views are rather holistic, and here and there rather hawkish in terms of the technological power balance between the U.S. and U.S.S.R. But he believes the U.S. is in deeper trouble than the current science and security advisory apparatus realizes and this has everything to do with innovation.

He would like to see a more strategic analysis of technological balance data provided to the White House. Technology, economics, and security need combined analysis, he says, and the Administration is currently not getting it. "On some developments critical to U.S. long-term security, apparently nothing is supplied at all."

But on the domestic side of technology policy, Boretsky has several suggestions, including:

- Substitute one half of the present investment credits for tax credits and apply them to research and development aimed at technological innovation that would either enhance labor productivity, save materials, develop substitutes for raw materials, save energy, or develop truly innovative new processes and products.
- Reduce or preferably eliminate the capital gains tax on gains stemming directly from investments that go into new enterprises. The secondary gains would be taxed at the present 28% rate. "Such a policy would provide the additional incentives needed in the environment of progressively scarce capital to induce investors to take the larger-than-normal risk of investing in new technical enterprises."
- Besides having the Census Bureau publish its usual data on employment, man-hours worked, value added, etc., for various industries, add to the service data on best and worst performing industries. This would be a managerial monitoring tool leading to steps to improve performance in lagging industries.
- Establish a new Office of Industrial Technology & Productivity Enhancement in the Commerce Department. The office would do technology policy planning, measure the country's technology policy planning, measure the country's technology needs vis-a-vis level of effort, administer a network of university-affiliated centers for industrial technology, and support a network of regional productivity enhancement centers.

It wasn't Baruch's assignment to delve into the national security aspects of technological innovation—broadly or narrowly. The military aspects are left, understandably, to the Defense Department, National Security Council, and the intelligence community. But the nonmilitary aspects of security are fair game, and, in fact, strict focus on "domestic policy" may miss the point entirely.

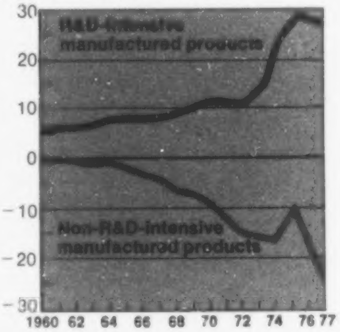
Indeed, William Winpisinger, president of the International Association of Machinists & Aerospace Workers, says the innovation study was a smoke screen. In testimony in November, he said, "The glut of corporate profits—21.2% this quarter—provides unlimited resources for lavish political contributions, extraordinary lobbying expenses, political and business bribery and kickbacks on an international scale, propaganda campaigns, front groups' foundations, and institutional advertising. Yet with all these extracurricular activities, we are asked to believe that the corporate state is having great difficulty financing industrial innovation. The truth is that the corporate state has difficulty financing what the corporate state chooses to have difficulty financing, and it has exactly as much innovation as it wants."

For every Boretsky there's a Baruch. And for every Baruch a Winpisinger. The innovation debate is so complex that its watchers and as-

Why U.S. technology needs a shot in the arm

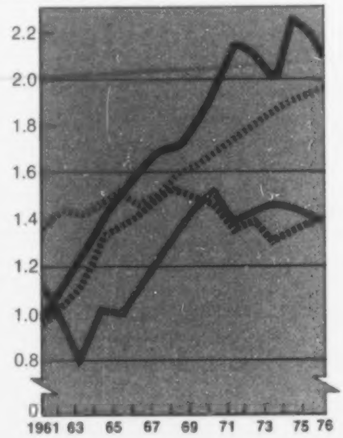
Export of research-intensive products begins to decline . . .

Trade balance, $ billions[a]



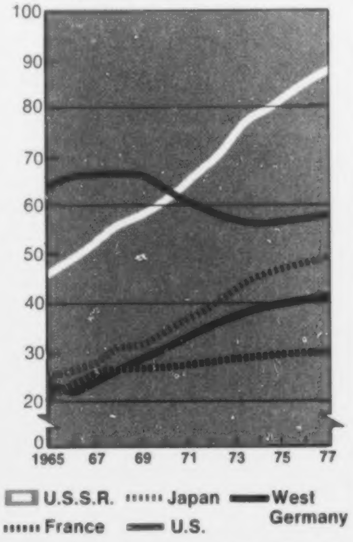
. . . while the R&D/GNP ratio falls below rest of industrial world . . .

R&D expenditures as % of GNP[b]



. . . and number of scientists and engineers also falls

R&D scientists and engineers per 10,000 labor force



[a] Exports less imports [b] Excluding government funds for defense and space R&D.
Source: Science Indicators—1978

sorted fans are turning now to Capitol Hill and a big Congressional Research Service (CRS) study that is slated to sum up everything known and believed about the subject. The study is being coordinated by CRS's Walter Hahn and is part of a voluminous study on economic change commissioned by the Joint Economic Committee.

The study so far indicates that there is no central theory of innovation. Thus, the search usually centers on scapegoats as prime causes for the so-called "lag."

One draft says, "Each fingerpointer has at least one other group to blame: too much government, irresponsible business, big labor, a consumer society, inflation and a faltering economy, or just plain 'them'—anyone from environmentalists to OPEC and from political opposites to foreigners."

Only one group in the country has tried to achieve a holistic perspective on innovation policy. It is the Center for Policy Alternatives under J. Herbert Hollomon at the Massachusetts Institute of Technology. Some ideas generated through that group are important to include because nowhere else is innovation studied more intensely than there.

The aim of innovation, the group contends, is not so much a growing economy but one that responds to change and challenge. It does not believe that government should intervene in the marketplace by supporting technological development in the civilian industrial sector. It believes that government should not brace up firms like Chrysler Corp. that cannot compete any longer. It believes that antitrust law should be enforced so that companies are penalized for not innovating. It believes the U.S. should learn from Japan.

"In no other developed country is there such a complete array of programs to encourage innovation," the center's Christopher T. Hill and James Utterback say in "Technological Innovation for a Dynamic Economy." These include grants-in-aid for the implementation of inventions, special development contracts and grants, arrangements for commercialization of new developments, support for capital equipment for new ventures, rapid tax writeoffs for new developments, low-interest loans for high-technology firms, special analysis and advice for small firms, special procurement policies for small businesses, 'open' research laboratories in all prefectures for the use of new and small firms, and no-interest loans for modernization of small firms. "The U.S. should consider adopting new programs of the kind now found in Japan," they say, adding: "Frequently, it is claimed that the risks of technological innovation are too great today, and that government should take actions to reduce that risk by, for example, subsidizing development of new technologies, weakening the antitrust laws, or rolling back environmental health and safety standards.

"The main message is just the opposite—government should take steps to encourage innovation by increasing the risks that firms face—not by increasing the risk of failure of new technology, but by increasing the risk that a firm will fail if it does not innovate."

The MIT plan, although bold, wouldn't hold much political water. Protectionism is expected to increase, not decrease, during the 1980's. And despite what the studies say about the comparative economies of Japan and West Germany, their stability is far more shaky than that of the U.S. Their own insecurities and their need for the U.S. market is the main force behind the flow of foreign investment capital to the U.S. Foreign technology, as some observers point out, is diffusing quickly to the U.S. But how the system shakes out during the 1980's, especially in the face of the rising tide of the Moslem world and the internal troubles besetting the Soviet Union is really anyone's guess. The very idea of competition over commercial property and profits may be going out of style in a world more and more interdependent. One doesn't trade in order to compete.

For example, foreign investment capital is practically surging into the U.S. from abroad. The U.S. semiconductor industry, once a scattering of relatively small companies bent on taking risk simply for the excitement of pushing back frontiers, is now being swallowed up by big foreign equipment makers. The consensus seems to be that the trend is bad for innovation in semiconductors but good for the information processing and computer industries. Equipment costs will continue to go down and technology will continue to spread across borders in healthy amounts as a consequence. Foreign countries are buying into U.S. know-how and are beginning to set up manufacturing facilities in the U.S.

In surveying global industrial activity, in fact, one comes away with the feeling of the awesome speed and volume of international technological investment. Some examples:

- International Telephone & Telegraph plans closing two unprofitable color television plants in Britain.
- Boeing plans to spend $300 million in Britain during the 1980's.
- Fujitsu, Japan's leading com-

Technological intensity of U.S. industry has declined from 1957–73 period to 1974–78

	1957–73			1974–78		
	Technology-intensive industries[a]		Nontechnology-intensive industries[b]	Technology-intensive industries[a]		Nontechnology-intensive industries[b]
	Total[a]	Chemicals and allied products		Total	Chemicals and allied products	
INDICATORS OF TECHNOLOGICAL INTENSITY						
Expenditures on R&D, all sources of funds as % of gross product originated (value added) average	14.4%	9.4%	1.3%	13.2%	9.6%	1.5%
Employment of scientists and engineers in functions other than R&D as % of total employment, average	3.5	5.6	0.8	2.8	4.5	0.8
Employment of craftsmen as % of "operatives and laborers" (census terms)	52.5[c]	42.8[c]	33.5[c]	49.8[d]	53.6[d]	38.0[d]
ECONOMIC PERFORMANCE						
Average annual growth in real output, % per year	5.5	6.0	3.8	2.7	2.4	1.1
Average annual growth in employment, % per year	1.5	1.5	0.8	1.1	1.0	−0.3
Average annual growth in real output per person employed (productivity), % per year	4.0	4.5	2.9	1.6	1.4	1.4
Average annual increase in inflation (increase in implicit price deflator), % per year	0.9	−0.3	1.6	7.4	7.9	7.9
Average annual foreign trade balance, $ billions	−$8.1	+$1.7	−$4.0	+$23.1	+$4.2	−$15.8

a Includes chemicals, nonelectrical machinery, electrical machinery and equipment, transportation equipment and missiles, and instruments and controls. **b** Comprises all industries not listed as technology-intensive, most notably textiles, apparel, iron, steel and nonferrous metals, and furniture. **c** Average for 1960–70. **d** 1976. **Source:** Prepared for C&EN by Michael Boretsky of the Department of Commerce. Based on data from the Bureau of Economic Analysis, Bureau of Census, Bureau of Labor Statistics, and National Science Foundation

puter manufacturer, studies the feasibility of a joint-marketing venture with TRW.

- Philips of the Netherlands expands and restructures its Japanese marketing operations to prepare for introducing its video-disk equipment there in 1981.
- Kuwait and Bahrain establish Bahrain-Kuwait Petrochemical Industries Co. in the first joint industrial venture between two Persian Gulf states.

The sheer volume and diversity of such news is dazzling and one cannot help but conclude that the competition is overpowering.

Whatever the merits of the Baruch exercise, the federal system, which is to say the people of the U.S., seems poised to draw on that reservoir of U.S. inventiveness—a force author Max Lerner labeled "The Underground River," in an essay written almost two decades ago. It is at once a corporate Main Street and counterculture phenomenon—goals for the era of international technology transfer as well as for the Age of Aquarius. The common theme is somehow a pairing of economics and the true nature of wealth.

So what should we make of all this stirring? What sort of a technology policy is being born in laboratories as well as in farms, towns, and co-ops? How can the notion of private intellectual property—technology under capitalism—be reconciled with the free flow of knowledge in a world at the brink of panic? Baruch hasn't addressed this. His theme, in a way, is to stem the tide of competition. Maybe author Gary Wills says it best in his book, "Inventing America," about Jefferson's philosophical groundings.

Jefferson felt, according to Wills, that all new gadgets simply re-exemplified the great Newtonian laws, that all "curious" mechanisms were little orreries (mechanical models of the planetary system) of nature.

"This explains," says Wills, "Jefferson's opposition to long or rigorous patent rights. No one can truly 'own' the 'invention' of things that work, since no one can own Nature, and all things work by the laws of Nature and of Nature's God. Jefferson was opposed to the individualist vision of private enterprise. All enterprise is public, is common. Not only does the earth belong to the living. So do all the forces driving the earth."

All this may appear far afield from the meager beginnings of national innovation policy that could die in months. But the notion of Jefferson's idea of mechanical gadgets being orreries and thus belonging to nature bears curious resemblance to the theology of Islam, a religion causing so much trouble for the U.S. today, and perhaps the Soviet Union tomorrow.

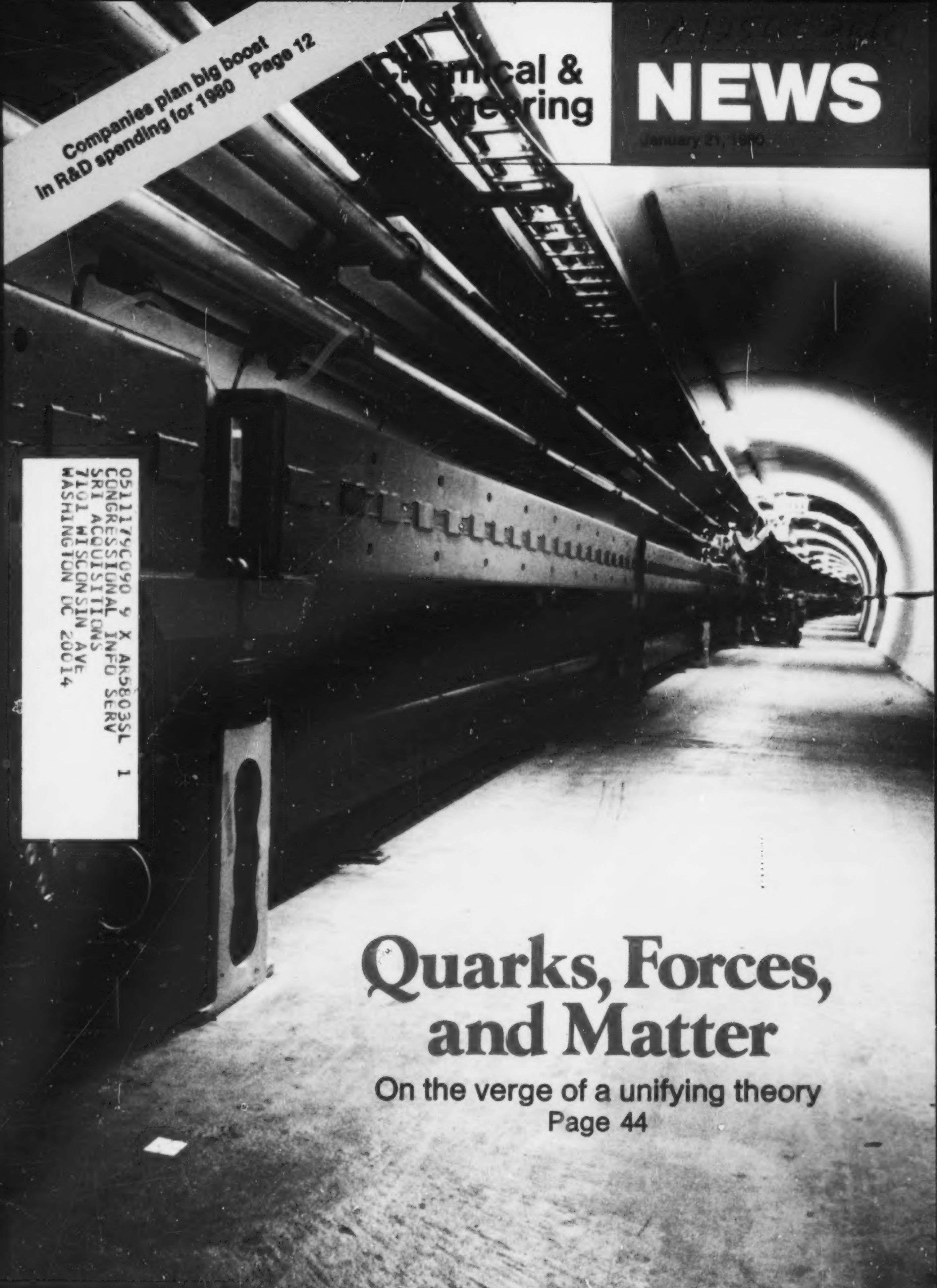
Baruch and Press would sound hollow to even the most moderate of ayatollahs, or to a more neutral sect of more spiritual Moslems known as Sufis, who believed technology was to be used not to master nature but to live with it. But one would have hoped that Baruch and Press would have paid attention to tides instead of waves. One suspects that much bigger things are going to drive human technics than a Press/Baruch perception of wealth and machines born somewhere in Victorian England.

A 3M Co. executive told C&EN recently: "We're becoming a have-not nation by our own hand. I'm not worried about 3M because we're already 46% offshore. But here in this country we're afraid to take risks for fear of being penalized by the regulators. Or take Three Mile Island. If that is a risk, I'll take that kind any day of the week.

"But you know, somewhere in the body of the American people there is a great pool of common sense. Somewhere down the line I'm hoping it will emerge again." □

Chemical & Engineering
NEWS
January 21, 1980

Companies plan big boost
in R&D spending for 1980 Page 12



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Quarks, Forces, and Matter

On the verge of a unifying theory

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R&D support starts 1980's with strong year

Largest U.S. chemical firms plan 14% increase in R&D funding in 1980, comfortably ahead of R&D inflation rate; job outlook continues good

William F. Fallwell
C&EN, New York

Research and development in the U.S. basic chemical industry is getting off to a much different start in the 1980's than in the 1970's. In contrast to the growing wave of corporate skepticism and budgetary clampdowns 10 years ago, R&D now enjoys its best level of boardroom appeal since the mid-1960's.

R&D budgets show it. C&EN's annual survey of R&D spending plans by the 17 largest basic chemical companies has turned up an overall estimated 14% gain in 1980 over 1979. Combined budgets this year will reach about $1.89 billion for all 17 companies, compared to $1.65 billion in 1979.

The 1979 figure is close to the initial estimate of $1.62 billion in C&EN's survey a year ago (C&EN, Jan. 15, 1979, page 12). Spending in 1979 rose 12% from spending of $1.48 billion in 1978.

These double-digit increases are welcome to the steadily increasing ranks of scientists and engineers in chemical R&D. Such increases are also necessary for increased staffs and projects in a time of double-digit inflation. Inflation in R&D trails the standard consumer price index of inflation but is still high. According to Dr. W. Halder Fisher of Battelle Columbus Laboratories, the U.S. industrial R&D inflation rate (the increase in cost per technical employee in R&D) rose to 7.6% in 1979 from 5.8% in 1978. In 1980, he predicts a jump to 10.7%.

However, chemical companies' R&D budgets are growing well above these inflation rates. That means companies will have another year of net increases to staffs and projects in 1980. In C&EN's employment outlook survey last fall (C&EN, Oct. 22, 1979, page 31), the expected increase in R&D staffs was 2% from mid-1979 to mid-1980, the same rate as in the previous 12 months.

Although a 2% annual employment increase looks small, it actually translates into a strong job market. Hiring will be much higher than this, since some R&D staff people will retire, and many others will transfer to other parts of the company.

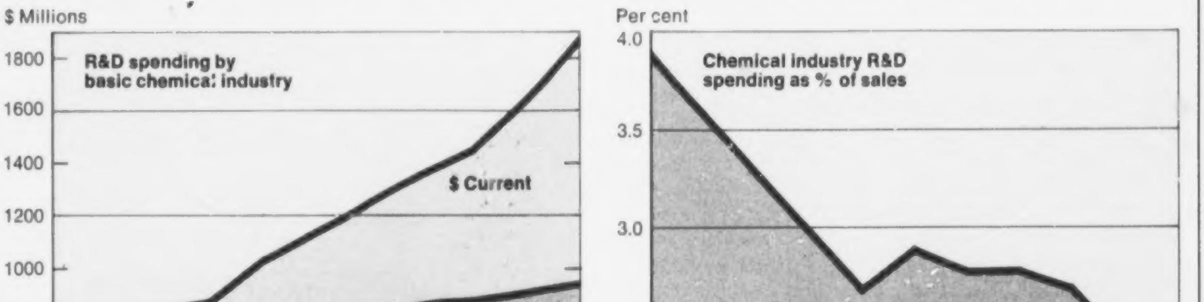
Similarly, the 14% budget increase (4% in constant dollars) that the current survey finds for R&D funding in 1980 is not meteoric. But like the job increase rate, the funding rate still means a vigorous time for R&D. The present funding rise is the seventh straight in constant dollars. Added up, this chain of increases has had a transforming effect. R&D budgets in 1980 will be double those of 1973 in current dollars and one third higher in constant dollars.

Even so, R&D funding has not kept up with the chemical sales pace. Combined R&D budgets as a percentage of sales in 1980 could inch up to 2.5% from 2.4% in 1979 if a mild U.S. recession touches the chemical industry. In 1979, the spurt in sales ran ahead of R&D funding, causing the drop to 2.4% from 2.7% in 1978.

R&D management tends not to place much weight on the R&D sales comparison in a year of high raw material inflation. Such inflation outpaces R&D inflation, leading naturally to a decline in R&D funding as a percentage of sales. The same thing happened in the wild commodity inflation of 1974, when R&D's percentage of sales dropped to 2.7% from 3.0% in 1973. However, as the 1975 recession cut deeply into the industry's financial performance, R&D rebounded to 2.9% of sales.

Chemical R&D spending in 1980 will stay well ahead of inflation in R&D costs . . .

. . . and may slightly exceed 1980 growth in basic chemical industry sales



a Estimates. **Sources:** C&EN survey, Battelle Columbus Laboratories

Du Pont leads the field in R&D support with large increases in 1979 and 1980

	Worldwide R&D spending[a]								Change from previous year		R&D spending as % of sales	
$ Millions	Planned 1980	Actual 1979	Planned 1979	1978	1977	1976	1975	1974	1980	1979	1979	1975
Air Products	$ 27	24	23	23	24	19	16	11	13%	4%	2.0%	2.2%
Akzona	27	23	24	23	20	18	17	16	17	0	2.3	2.6
Allied Chemical	75	67	67	58	53	42	35	31	12	16	1.5	1.8
American Cyanamid	140	125	120	108	96	83	73	64	12	16	4.1	3.9
Celanese	100	91	93	83	77	70	64	58	10	10	2.9	3.2
Diamond Shamrock	50	42	40[b]	36	29	24	20	14	19	17	1.8	2.0
Dow Chemical	310[b]	270	265	232	203	188	167	149	15	16	2.9	3.4
Du Pont	490[b]	425	403	377	367	353	336	344	15	13	3.4	3.6
Ethyl	na	na	na	25	28	25	19	25[c]	na	na	na	1.8
W. R. Grace	44	40	41	41	34	30	30	32	10	−2	0.8	1.0
Hercules	53	46	45	40	37	35	30	30	15	15	1.9	2.1
Monsanto	195	160	160	144	132	114	116	87	22	11	2.6	2.9
Olin	na	na	26[b]	25	25	25	24	19	na	na	na	1.6
Pennwalt	na	na	26[b]	23	21	19	16	14	na	na	na	2.5
Rohm & Haas	62	54	55	49	45	43	45[c]	39[c]	15	10	3.4	3.9
Stauffer Chemical	45	38	39	34	33	29	24	20	18	12	2.5	2.6
Union Carbide	174	163	165	156	156	142	120	94	7	4	1.8	2.0
TOTAL[d]	**$1792**	**$1568**	**$1540**	**$1404**	**$1305**	**$1190**	**$1093**	**$989**	—	—	**2.4%**	**2.7%**
ANNUAL CHANGE[d]	**14%**	**12%**	**10%**	**8%**	**10%**	**9%**	**11%**	**19%**				

a Earliest company estimate. **b** C&EN estimate. **c** Includes activities later deleted. **d** For 14 companies with complete data for all years; per cent figures are averages. **na** = not available.

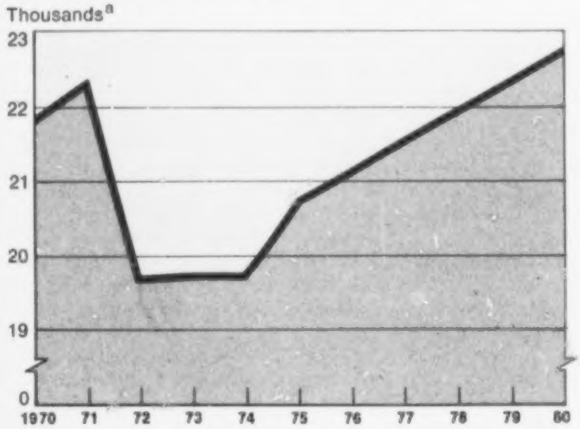
Despite its falling percentage of sales, R&D funding in the chemical industry is exhibiting a remarkable stability in another respect. For accounting purposes, R&D is a variable cost charged immediately to current revenue. This raises the temptation in hard times to trim R&D to increase earnings. Although there are still some signs of earnings-related fluctuations in some companies' R&D support, the industry as a whole has taken a successful stand against this practice.

A simple rundown of quarterly R&D outlays and corporate earnings shows R&D's newfound independence. For a group of six companies with such figures since the first quarter of 1976, R&D spending moved up steadily, climbing 39% by third-quarter 1979. Over the same period, earnings rose just 3% after negative gyrations during 1976, 1977, and 1978. These companies are American Cyanamid, Celanese, Diamond Shamrock, Dow Chemical, Monsanto, Stauffer Chemical, and Union Carbide.

In other words, R&D held up well in the second half of the 1970's even though the chemical business as a whole had several tedious years under constant downward earnings pressure. Since the general outlook for the industry is brighter for the early 1980's, R&D may do even better.

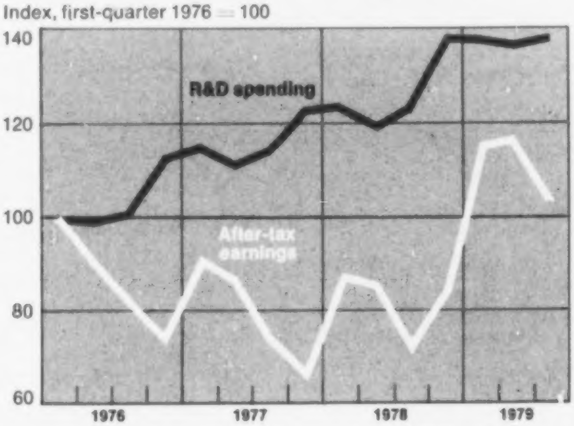
Some individual company moves support this possibility. Most important, Du Pont is again raising its R&D budget strongly after nearly a decade of restraint. From 1969 through 1978, Du Pont's R&D budget rose an average of only 3% per year, whereas the overall average annual

Employment continues to climb for chemical R&D scientists and engineers . . .



a Full-time equivalent R&D scientists and engineers in basic chemical industry at beginning of year. **Sources:** National Science Foundation, C&EN estimates.

. . . with steadily increasing budgetary support independent of earnings swings



Source: Combined data from American Cyanamid, Celanese, Diamond Shamrock, Dow Chemical, Monsanto, Stauffer Chemical, and Union Carbide increase in the chemical industry was 7%. Since Du Pont has by far the largest research establishment in the industry, performing about one fourth of all the industry's R&D, the company's pause for reshuffling in the 1970's was a significant drag on the industry's overall figures.

Du Pont appears now to be in a new R&D growth period. After a 13% budget increase in 1979 to about $425 million, the company plans about a 15% increase in 1980. This works out to a budget of about $490 million. In contrast to its drive to cut down pioneer projects earlier in the 1970's, Du Pont now shows some signs of a fresh initiative in basic research. One example is the molecular genetics (gene splicing) program the company started last year.

Besides Du Pont, another company that had a slow period in R&D growth in the late 1970's may be stepping up the pace. Union Carbide, after doubling its R&D funding from 1973 through 1977, tightened up in the next two years. The budget was flat in 1978 and grew only 4% in 1979. However, for 1980, the company plans a 7% increase to $174 million.

By contrast, the other two companies in the industry's top four in R&D support, Dow Chemical and Monsanto, are pressing ahead with large, regular funding increases. Solidly number two in the industry's R&D, Dow plans about a 15% budget increase in 1980 after 16% in 1979. This would bring the company's 1980 spending to $310 million.

Monsanto plans the industry's largest percentage increase in funding in 1980 with a 22% gain to $195 million. Now third largest in the industry's R&D funding, Monsanto plans increases in basic projects this year after doubling its budget since 1974.

As a result of the budget increases this year by the industry's top four in R&D, their share of the industry's total funding remains large, about 62%. Hence, R&D is still a concentrated activity, with proportionately more activity by the top four than their 55% share of sales among the 17 companies in C&EN's survey.

Still, many smaller companies plan sizable increases in R&D support in 1980 after strong gains in 1979. Increases amount to 12% in 1980 after 16% in 1979 at Allied Chemical (which is keeping an increased R&D emphasis and has instituted a scientific advisory committee whose chairman sits on the board of directors), 12% after 16% at American Cyanamid, 19% after 17% at Diamond Shamrock, 15% both years at Hercules, 15% after 10% at Rohm & Haas, and 18% after 12% at Stauffer Chemical. □

Companies blame U.S. for agent orange ills

Five chemical companies are not going to content themselves with merely being defendants against charges by a group of Vietnam veterans. The veterans say that the defoliant agent orange, which the companies supplied to the U.S. government, may have been the cause of birth defects and other maladies suffered by the veterans and their families.

The five companies—Dow Chemical, Monsanto, Hercules, Diamond Shamrock, and Thompson-Hayward, a subsidiary of North American Philips—have filed a third-party action against the federal government. The action alleges, in effect, that if any harm was done, it was the fault of the government and not of the companies that manufactured agent orange (C&EN, Jan. 14, page 13).

The action filed against the government in Federal District Court in Westbury, N.Y., accuses the government of negligent misuse of the chemical and also accuses the U.S. of failing to inform servicemen of the potential dangers associated with exposure to agent orange. The defoliant is a herbicide made of 2,4,5-trichlorophenoxy-acetic acid, and 2,4-dichlorophenoxy-acetic acid. It also contained trace amounts of highly toxic dioxins.

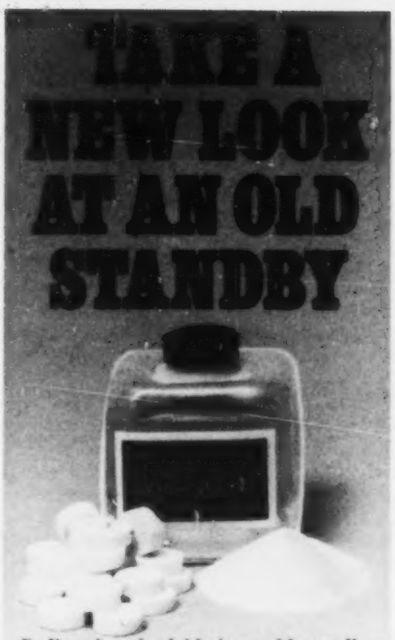
The action brought by the chemical companies was in response to a class action suit brought against them last year by a Vietnam veterans' group on behalf of more than 3000 veterans.

The group is seeking the creation of a trust fund for the relief of victims of agent orange. The fund would be financed by the chemical companies and administered by the court.

Although the companies say they believe that the veterans' group has no case, the third-party complaints have been filed to protect them in case a jury determines liability.

The complaints were filed separately earlier this month, but they resemble one another on many counts. A company spokesman says that the firms are cooperating closely on the case. "Since we are being sued as a class, we are defending as a class," he says.

The chemical companies claim that they manufactured agent orange to government specifications and that they were required to supply it to the government under the Defense Production Act. They say that the gov-



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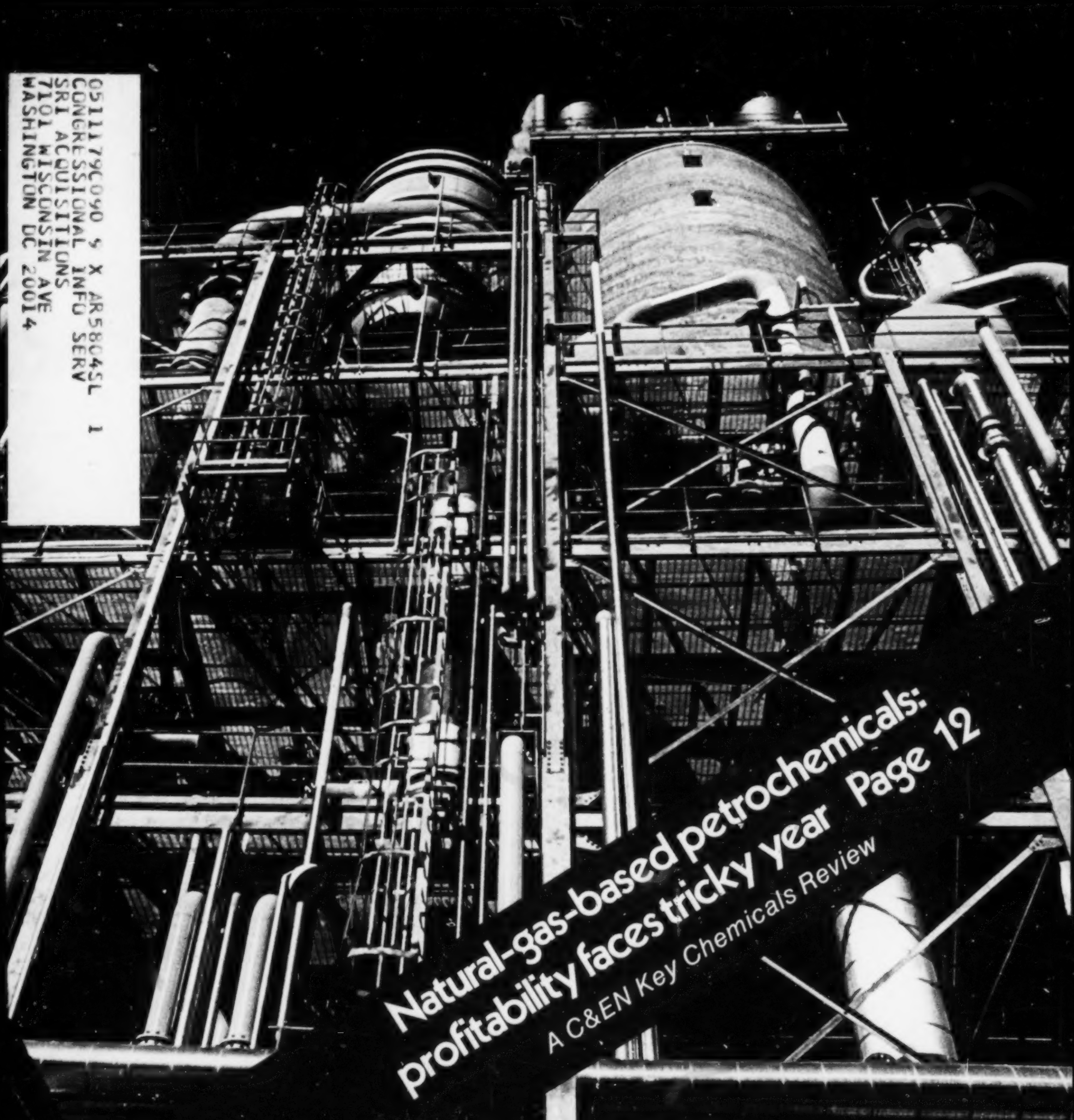

Natural-gas-based petrochemicals: profitability faces tricky year Page 12

A C&EN Key Chemicals Review

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Cover: W. R. Grace & Co.'s ammonia/urea complex at Memphis

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- ***Shipments of chemical products*** *will grow at least 12% this year despite economic slowdown, Commerce says.* ***Page 7***
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- ***Three candidates*** *are running for vacancy in ACS director-at-large seat, two of them nominated by petition.* ***Page 55***

FOURTH-QUARTER EARNINGS VARY WIDELY

Fourth-quarter 1979 earnings performance from 16 basic chemical companies that have reported thus far varies widely. They range from Monsanto's 59% drop in fourth-quarter profits from the same period last year to Texasgulf's 195% increase.

Combined, the 16 companies show an average 19.4% increase in after-tax earnings on a sales increase of 19.3% for fourth-quarter 1979 over fourth-quarter 1978.

For the full year, the 16 companies show an outstanding earnings gain of 37.5% over the full year of 1978. Sales for 1979 increased a much slower 20.2%.

However, the blush may be off the rose. The two companies that have reported declining earnings for the quarter—Celanese and Monsanto—attribute much of their problems to their fibers operations. In previous recessions, fibers have led the downturn and a decline in this area now could portend things to come for other chemicals.

John D. Macomber, president and chief executive officer of Celanese, says that the company's chemical business sustained its favorable performance in the fourth quarter and turned in a record year. Celanese had fourth-quarter declines in U.S. sales of cellulosics and in the international portions of its fibers business. Despite this, Macomber says, these areas registered healthy full-year results. Polyester, nylon, plastics, and specialties continued to be affected by weak product demand, according to Macomber.

Monsanto chairman and president John W. Hanley sounds optimistic in the face of a gloomy report. "We believe we made progress in positioning Monsanto to capitalize on the profit growth for the decade of the 1980's, despite the fact that 1980 itself will be affected by the recessionary factors that became so apparent to us late in the fourth quarter of 1979," Hanley says.

Inventories are beginning to be a problem at Monsanto. According to Hanley, "During the fourth quarter, inventory corrections by our customers resulted in a significant drop in shipments and a modest buildup in inventory at our own plants. Products for the automotive and residential construction industries in the U.S. were particularly hard hit. Concurrently, high feedstock and raw material costs placed heavy pressure on profit margins."

High raw material costs are a problem even for those companies that have shown profit increases for the fourth quarter. At Hercules, which had an 8% increase in earnings in the fourth quarter, Alexander F. Giacco, president and chief executive officer, says, "As a result of the spiraling costs of raw material and energy in the fourth quarter, gross profits and pretax earnings were adversely affected. For the year as a whole, raw material costs were up 15.7% and energy costs were up 20.9%.

Even at Rohm & Haas, which had a 39% increase in earnings for the fourth quarter, feedstock costs were a concern. Board chairman Vincent L. Gregory Jr. says that feedstock costs were up 27% over fourth-quarter 1978.

One company still holding up well is Union Carbide, whose earnings held up longer than those of other major chemical companies in the previous recession in 1974 and 1975. Carbide reports an earnings jump of 28% before nonrecurring items in the fourth quarter on a 15% sales increase. For all of 1979, company earnings rose 51% and sales gained 17%.

In another announcement, Carbide spokesmen told security analysts last

Earnings declined at Celanese and Monsanto in fourth quarter

	Fourth-quarter 1979						Full-year 1979					
					After-tax income as % of sales						After-tax income as % of sales	
$ Millions	Sales	Change from 1978	Earnings[a]	Change from 1978	1979	1978	Sales	Change from 1978	Earnings	Change from 1978	1979	1978
Air Products	$ 317.4	15%	$ 31	42%	9.8%	8.0%	$1271.7	18%	$106.6	33%	8.4%	7.5%
Akzona	275.6	23	6.9	25	2.5	2.4	1012.4	17	25.6	23	2.5	2.4
Celanese	814.0	18	29.0	−17	3.6	5.1	3146.0	21	143.0	28	4.5	4.3
Diamond Shamrock	666.1	40	58.5	27	8.8	9.7	2351.6	29	178.1	28	7.6	7.7
Ethyl Corp.	431.1	14	22.0	8	5.1	5.4	1657.0	16	97.5	18	5.9	5.8
First Mississippi	61.4	44	5.5	b	9.0	b	237.4	51	14.8	2860	6.2	0.3
Freeport Minerals	130.3	59	26.0	177	20.0	11.5	487.7	60	101.4	224	20.8	10.3
Hercules	596.0	18	26.8	8	4.5	4.9	2350.0	21	144.5	40	6.1	5.3
International Minerals & Chemical	443.5	28	37.8	35	8.5	8.0	1642.5	17	140.0	24	8.5	8.1
Monsanto	1547.9	19	18.2	−59	1.2	3.4	6195.2	23	338.4	12	5.5	6.0
Olin	441.0	8	15.5	5	3.5	3.6	1800.0	14	71.1	13	4.0	3.9
Pennwalt	283.3	22	11.9	13	4.2	4.5	1079.3	17	48.0	7	4.4	4.9
Rohm & Haas	387.8	26	18.2	39	4.7	4.2	1590.5	27	95.5	65	6.0	4.4
Stauffer Chemical	369.7	14	35.9	6	9.7	10.4	1526.2	15	136.0	8	8.9	9.5
Texasgulf	220.3	29	44.2	195	20.0	8.8	789.3	31	136.9	173	17.3	8.3
Union Carbide	2396.0	15	131.9	28	5.5	4.9	9176.2	17	556.4	51	6.1	4.7

a After-tax, before extraordinary or nonrecurring items. b Deficit.

week to expect a large nonoperational gain in earnings in 1980, about $343 million or $5.15 per share, as a result of four major accounting changes. Well over half of this, $214 million or $3.23 per share, comes from catching up with accumulated deferred investment tax credits. ☐

Airco develops solvent recovery system

Metal, wood, plastics, and paper coating plants may be spared the need to convert to radiation-cured, high-solids, or water-based coatings systems if a newly introduced solvent recovery system proves economically feasible with existing conventional coatings.

Airco Industrial Gases, a division of Airco, Murray Hill, N.J., has developed a technique to condense more than 99% of solvents from curing oven effluent with liquid nitrogen while using nitrogen gas to maintain inert atmospheres in ovens. Equipment can be fitted to existing ovens.

Airco Industrial Gases polymers and coatings manager Donald Rothchild says the system virtually eliminates stack emissions, allowing conventional plants to operate within air quality standards. He estimates coaters can save 40 to 90% of present costs by using less energy to heat ovens and plant air and by taking a credit for recovered solvent. Cost savings are only 40% with massive, metal parts of high heat capacity but can rise to 90% with paper or plastics coatings. Solvent credits vary according to whether solvent can be resold or used as fuel.

The company also is exploring uses of the system in production of synthetic rubber, polypropylene, and vinyl chloride.

One key to the technology is ability to maintain solvent partial pressures of several hundred millimeters of mercury in nitrogen recirculated at high velocity through the oven and bled at a low rate to the condensation section. Conventional ovens draw 10,000 cu ft of plant air into the oven per gallon of solvent to dilute solvent vapors below explosion limits. These air volumes must be replenished from outdoors and heated.

Evaporation of liquid nitrogen from solvent condensation furnishes nitrogen gas to maintain the inert atmosphere by injection into oven entry and exit ports. Because evaporation of liquid nitrogen produces more than the needed amount of gas, the excess, blowing from the entry and exit, stops air from getting in.

Airco Industrial Gases will license the technology to other manufacturers. The firm itself will start producing 120 gal-per-hour modules in April and 45 gal-per-hour units in May. A 350 gal-per-hour system will be available on receipt of special orders.

In a trial of the process on one 18,000 sq-ft-per-hour fabric coating line of a New England textile plant, cost savings were more than 70%, Airco Industrial Gases engineers estimate. They calculated savings of 80 cents per hour for elimination of 160,000 Btu per hour previously needed to heat plant air; reduction of oven heating costs to $1.80 per hour from $3.75 per hour by lowering power consumption to 36 kw per hour from 75 kw per hour; and a credit of $6.30 per hour for 9 gal per hour of recovered solvent. Costs increased 30 cents per hour for the 300 cu ft per hour of nitrogen used. ☐

Higher prices to spark 12% gain for chemicals

Despite an expected slowdown in overall economic growth in 1980, shipments of chemical products will continue to rise sharply. That, at least, is the way industry analysts in the Department of Commerce see it.

Last year, shipments of chemicals and allied products increased nearly 17% to $152 billion. This year, the department looks for a further increase of at least 12% (to $170 billion) and perhaps as much as 22% (to $185 billion). This despite the overriding assumption that the U.S. economy as a whole will contract during the first half of the year and recover only slowly during the second half, after adjustment for inflation.

The growth projected for chemicals is more a matter of higher prices than increased production, however. This is clear when you look at forecasts, published in the 1980 edition of Commerce's annual "U.S. Industrial Outlook" publication, for individual product lines. In general, growth in shipments measured in constant dollars will be only a third or less as great as when measured in current dollars. Even so, synthetic rubber is the only segment of the chemical industry for which Commerce expects output to decline this year.

Among chemicals, prospects for 1980 look strongest for nitrogen and phosphate fertilizers, both expected to show real growth of 8%. But Commerce's forecast was made before the Administration embargoed grain shipments to the Soviet Union and hinges to a considerable degree on increased exports of both agricultural products and fertilizer materials to the U.S.S.R. Other forecasts also may be a bit optimistic; most of them were made last fall when Commerce industry analysts admittedly "envisaged a stronger economy in 1980 than now appears to be in prospect." ☐

Higher prices will account for most chemical growth this year

$ Billions	Value of shipments 1980	Value of shipments 1979	% change 1980 Actual	% change 1980 Real[a]
Organics	$37.3	$33.9	10.1%	2.9%
Drugs	17.9	16.1	11.6	4.2
Plastics	18.9	16.5	14.5	5.0
Inorganics	14.2	12.6	13.0	3.1
Cosmetics	9.0	8.1	12.0	4.8
Fertilizers[b]	8.1	6.5	25.1	8.0
Coatings	8.0	7.5	7.0	0.5
Detergents	7.3	6.4	14.0	3.5
Pesticides	3.7	3.3	14.0	3.0
Synthetic rubber	3.0	2.9	2.2	−5.2

a Adjusted for changes in selling prices. b Nitrogen and phosphate fertilizers only. **Source:** Department of Commerce

Ammonia imports to be limited from U.S.S.R.

Reversing an earlier decision, President Carter last week imposed a one-year, 1 million ton quota on anhydrous ammonia imported from the U.S.S.R.

Ammonia is imported under a long-term agreement between the Soviet Union and Occidental Petroleum, Los Angeles. Under the agreement, increasing quantities of ammonia were to be imported over the next several decades. In exchange, Occidental was to export to the Soviet Union 1 million tons of superphosphoric acid per year for the next 18 years. The Carter Administration is now considering a possible termination of phosphoric acid exports, a cutoff that would cost Occidental more than $160 million this year.

On Dec. 11 when Carter, overruling the U.S. International Trade Commission, decided that it was in the national interest not to impose import quotas on ammonia, Occidental contracted with the Soviets for a 47% addition to these imports. This year, the new import total was to have been 1.4 million tons, up from 950,000 tons in 1979. Last year's imports were valued at about $100 million.

Last October ITC recommended that ammonia import quotas be set for three-year periods. ITC believed then that a rapid increase in imports

Profits test due for gas-based petrochemicals

After better than expected sales and earnings in 1979, conditions may be tougher in 1980 for ammonia, urea, methanol, and formaldehyde

The leading U.S. petrochemicals based predominantly on natural gas—ammonia, urea, methanol, and formaldehyde—are in many respects the lightweights of the petrochemical world. They are smaller in molecular size, commercial sales and profits, and price structure than their glamorous distant cousins, the olefins and aromatics such as ethylene and benzene derived more from oil.

This distinction is no less true in the uses of the two petrochemical groups. The olefins and aromatics go largely into relatively high-value polymers such as the leading plastics, fibers, and rubber. The gas-based group, by contrast, winds up in two main lower-value markets, fertilizer and polymeric adhesives, whose leading outlet is in construction materials.

Du Pont's new complex at Deer Park, Tex., has 200 million gal methanol capacity

Both petrochemical groups felt fully the moderate physical growth and meteoric dollar growth of the 1970's, and both face a rougher business climate in 1980 than in 1979. However, the slope of the 1970's rise and the difficulties looming in 1980 differ considerably for oil- and natural-gas-based chemicals. For an immediate 12-month outlook on the four gas-based Key Chemicals, see the following pages. A similar outlook on five leading oil-derived Key Chemicals appeared in C&EN, Nov. 19, 1979, page 10.

For both groups of petrochemicals, 1979 turned out far better than expected. Although the ingredients of a business slowdown and resulting cost-price squeeze seemed close a year ago, a fresh buying wave from U.S. consumers and non-U.S. export markets sent petrochemicals to new heights as the year unfolded.

For the four leading gas-based petrochemicals, combined production growth in 1979 was 4.7% to 61.8 billion lb instead of falling 2% as had been feared at the beginning of the year (C&EN, Jan. 22, 1979, page 10). Average unused nameplate capacity shrank from 23% in 1978 to 18% in 1979, and for three of the four chemicals—ammonia, urea, and methanol—effective capacity use reached high levels in operating plants.

The high operating rates helped producers pull up prices, which rose a combined 33% in 1979 from 1978 to an average of 5.7 cents a lb. For 1980, if producers barely pass through expected increases in natural gas costs, prices will rise another 19% to an average of 6.8 cents a lb. The ability to do this in the face of a possible recession in the U.S. is the biggest worry for producers. Any shortfall could cut into profits.

In total production value, the four gas-based petrochemicals rose 37% in 1979 from 1978 to $3.53 billion. In 1980, the rise could be another 22% to $4.3 billion.

The dollar figures for the four gas-based petrochemicals are telling evidence of the general difference in business from the oil-based group. Although physical volume for the two groups was not much different in 1979—61.8 billion lb production for the gas-based chemicals and 65.8 billion lb for the oil-based group—the oil-based chemicals were worth more than three times as much. Production value of the oil-based chemicals came to $11.3 billion, compared to $3.53 billion for the gas-based group. The value rise in 1979 from 1978 was 37% for the gas-based group and 39% for the oil-based group.

Prices show a similar divergence. The average price of 5.7 cents a lb for the gas-based chemicals looks like a bargain beside the average 17.1 cents a lb for the oil-based petrochemicals. Prices for the oil-based chemicals rose 26% in 1979, a bit less than the average 33% rise for the gas-based group.

Although natural-gas-based chemicals kept pace in dollar terms with oil-based petrochemicals in 1979, performance gains for the 1970's as a whole were considerably less. From 1969 through 1979, the gas-based group climbed a combined 54% in production, 326% in value, and 185% in price. Although this isn't small, it pales beside the corresponding gains for oil-based petrochemicals—81% in production, 680% in value, and 328% in price.

To some extent, the lesser dollar rise for natural-gas-based chemicals results from the difference in raw material cost increases. Although all such costs soared in the 1970's, cost of natural gas went up less on average than that of oil. Oil-based chemicals such as ethylene have reflected this disparity, as natural gas liquids have been substituted as much as possible for oil-based naphtha as feedstock in the newer heavy-liquids cracking plants.

Although their advantageous cost theoretically might give natural-gas-based chemicals some market edge over oil-based chemicals, little practical market share has changed hands. One example is the growing shift to methanol from ethylene as the source of acetic acid. However, for the most part, end products are simply too different in the two groups, and future natural gas supplies too uncertain. Hence, lack of assured natural gas may block low-cost plants for ammonia and methanol just as it has for ethylene and propylene.

William Fallwell, C&EN New York, and Bruce Greek, C&EN Houston

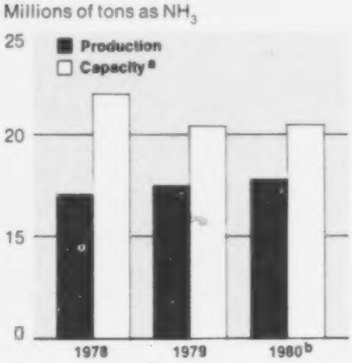
Key Chemicals

Ammonia

NH_3

- ***Demand unsettled***
- ***Capacity flat***
- ***Prices well up***

PRODUCTION/CAPACITY



[a] First quarter. [b] Excluding up to 15% additional capacity presently shut down but operable if economic conditions improve.

HOW MADE

Catalytic reaction of nitrogen from air and hydrogen made by reforming natural gas (methane)

MAJOR DERIVATIVES

Nitric acid 20%, urea 20%, ammonium phosphate 15%

MAJOR END USES

Fertilizer 80%; plastics, resins, and fibers 10%; explosives 5%

FOREIGN TRADE

Exports—rising to about 500,000 tons in 1980; imports—rising to more than 1.5 million tons

PRICES

$120 a ton at plants

COMMERCIAL VALUE

$2 billion for total 1980 production, $1.8 billion in 1979

An improving year for ammonia in the U.S. suddenly has dissolved in suspense after the government's cutoff of most of this year's grain shipments to the Soviet Union. As a result, forecasting ammonia demand in its dominant use, fertilizer, can only be called a game.

U.S. ammonia production still could rise to nearly 18 million tons in 1980 from last year's 17.5 million tons if the heavy political winds set up side currents. That is, if U.S. grain shipments blocked from the Soviet Union find other international markets, if as a result U.S. grain prices don't weaken too much, if planted acreage in the U.S. doesn't fall sharply, if U.S. longshoremen don't block the remaining grain shipments to the Soviet Union, and if—as it now appears—ammonia imports to the U.S. will be curbed, especially from the Soviet Union. President Carter has effectively pruned Occidental Petroleum's planned 1980 ammonia imports from the Soviet Union from 1.4 million metric tons to 1 million metric tons.

One of the few sure things about ammonia is that prices will rise as raw material natural gas (methane) costs increase. But producers wonder whether price rises will cover increases in production costs. So far, ammonia prices have managed a fair recovery from their severely depressed levels a year ago, moving up about 50% to $120 per ton.

Another sure thing for ammonia is that plenty of U.S. plant capacity exists if economic incentives lure it all into operation. Put most conservatively, if production slips to 17 million tons in 1980, considered in the industry a floor level, capacity use will barely exceed 70% of an estimated 24 million tons of operable nameplate capacity. This capacity includes up to 15%, or 3.6 million tons, currently shut down, leaving operating capacity at 20.4 million tons. More liberally, if 1980 production reaches 17.8 million tons, the use rate would be 87% of operating capacity.

Ammonia use continues to rise faster than production. The gap between the two will stay filled by imports, which come not only from the Soviet Union but from Canada, Mexico, and Trinidad, among other sources. U.S. consumption probably will exceed 20 million tons in 1980 unless farmers cut fertilizer use drastically or fertilizer exports drop suddenly.

The trade balance in ammonia is more complicated than it seems from ammonia figures alone. More than 10% of ammonia use in the U.S. goes to products eventually exported. Most of these are fertilizer, particularly diammonium phosphate and urea, in addition to basic ammonia.

During the fertilizer year ended June 30, 1979, exports of nitrogen-containing fertilizer apparently exceeded imports, including ammonia, based on nitrogen content. In terms of nitrogen, more than twice the amount of diammonium phosphate was exported than of third-ranking anhydrous ammonia. Urea is the largest nitrogen-containing export.

During the current fertilizer year, exports have been forecast to hold at about last year's level, more than 2 million tons of nitrogen. The reason for the leveling off is basically one of supply. Production of urea is running at practical plant capacity on an annual basis. Diammonium phosphate production appears limited by availability of raw material phosphoric acid.

The favorable trade balance in nitrogen for the U.S. will drop, although possibly not disappear, during calendar year 1980 because of higher ammonia imports. If Soviet imports are further curbed and if prices for U.S.-made ammonia rise substantially, the balance could remain positive for another year.

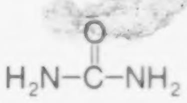
U.S. sales of fertilizer containing nitrogen could fall during 1980, depending on prices of fertilizer and grain. Increasing costs of natural gas certainly will cause some price increase for fertilizer containing nitrogen. But if grain prices hold or slump, farmers are likely to defer buying fertilizer.

The change in ammonia and grain prices can't always be translated into fertilizer sales, but one industry source estimates that a 10% rise in the price of nitrogen in fertilizer and a 10% decline in corn price could mean a 10% decline in unit (physical, not dollar) volume in fertilizer.

However, taking into account the difficult price situation in grain, prices of nitrogen in fertilizer may not rise 10%. The result then could be another year of less than satisfactory profits for U.S. ammonia producers.

Key Chemicals

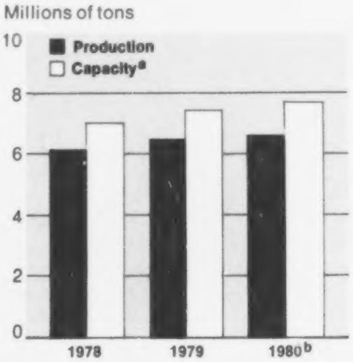
Urea



$H_2N-\overset{\overset{\displaystyle O}{\|}}{C}-NH_2$

- ***Demand strong***
- ***Capacity limited***
- ***Prices well up***

PRODUCTION/CAPACITY



a First quarter. b Excluding up to 5% additional capacity presently shut down but operable if feedstock ammonia and carbon dioxide become available economically

HOW MADE

Reaction of ammonia and carbon dioxide under pressure

MAJOR DERIVATIVES

Urea-formaldehyde resins 10%, melamine resins 5%

MAJOR END USES

Fertilizer 75%, adhesives and plastics 15%, animal feeds 5%

FOREIGN TRADE

Exports—up to about 1.8 million tons; imports—up to about 1.6 million tons

PRICES

From $130 for fertilizer grade to $175 per ton for industrial grade; spot prices close to contract

COMMERCIAL VALUE

$900 million for total 1980 production, $780 million in 1979

Urea producers in the U.S. ended 1979 with operations running all out and expect the same in 1980. Production of this favored fertilizer material again will be slightly limited by availability of raw material carbon dioxide and ammonia but probably will increase slightly. Output of urea could be 6.6 million tons this year following 6.5 million tons in 1979.

In contrast to ammonia, more urea could be sold if producers could make it. Production continues to push capacity ceilings because of good U.S. demand for solution fertilizer, most often UAN's (urea-ammonium nitrate), and because of booming exports.

In 1980, barring any major decline in U.S. fertilizer use or a collapse in exports, urea plants will be run at about 80% of total nameplate capacity of 8.2 million tons. This includes about 500 million tons not operating for lack of economical raw materials. A more realistic rate of capacity use in plants actually running would be 86%.

This operating rate is considered high, given urea's dependence on ammonia in recent years. An even higher operating rate might be possible but would require either more ammonia production, not necessarily desired, or an outside source of carbon dioxide, usually too expensive.

Actually, an 86% operating rate would be something of an achievement in 1980. Besides the carbon dioxide problem, plant maintenance concerns producers. Because of the export market, in 1979 producers shifted production up and down, in relation to seasonal demand for fertilizer, less than is usual. Some maintenance pauses were skipped. As a result, in 1980 deferred maintenance could take out more capacity than might usually be expected, depending on what problems turn up in equipment when plants are finally shut down for inspection.

In compensation, some upside flexibility exists in capacity of certain urea plants that have a relatively large output of solution fertilizer as the final product. On balance, with a nod toward conservatism in the face of an uncertain fertilizer sales year, market sources estimate a small increase in urea production as probable for 1980, perhaps 2 to 3%.

Behind some of urea's strong business is increased market share. Urea-containing fertilizer solutions and solid fertilizer urea, the latter sold usually as "prills" or small granules, continue to take some of the final market for nitrogen-containing fertilizer away from anhydrous ammonia and ammonium nitrate. Ammonia, even though it has a higher nitrogen content, suffers from shipping accidents and equipment cost in application. A further advantage for urea in some forms is slow (controlled) release of nitrogen.

Solid urea also is gaining slowly in its share of the nitrogen fertilizer used to make bulk blends along with fertilizer containing phosphorus and potassium, the other two principal plant nutrients. However, the big growth in this market is over for urea. Now growth is from a larger base and is more affected by fertilizer demand increases.

Both solid and liquid forms of urea go into animal feed. This use, something over 300,000 tons a year, has little growth forecast for 1980. Competition from other forms of protein nitrogen such as soybean meal looms as an expected damper on feed applications of urea.

Use of urea in making resins (about 15% of the total urea market) in 1979 grew instead of falling as had been widely expected. The reason was that a decline in housing, the dominant use area, came later than expected. When housing starts decline, demand for urea-formaldehyde adhesive resins in plywood and particleboard declines. Although the annual rate of housing starts now has fallen, 17% in 1979 from 1978, the ripple effect on urea for resins is barely noticeable yet. A decline in this use is again forecast for 1980, but how much is uncertain.

Various other uses of urea-containing resins, such as paper chemicals, coatings, and melamines, are forecast to have modest growth or minor declines in the 1980 U.S. economy. The net effect of these uses on urea demand will be tiny.

On balance, use of urea in resins may slip less than 10% in 1980. Such a decline actually may be welcomed by producers, since it would free some urea for the tight fertilizer and export markets.

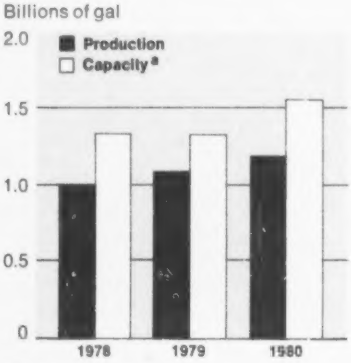
Key Chemicals

Methanol

CH_3OH

- ***Demand moving up***
- ***Capacity up modestly***
- ***Prices likely to rise***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Catalytic reaction of carbon monoxide and hydrogen made by reforming natural gas or from petroleum-derived heavy hydrocarbon mixtures

MAJOR DERIVATIVES

Formaldehyde 45%, acetic acid 10%, methyl tert-butyl alcohol 5%

MAJOR END USES

Polymers used as adhesives, fibers, and engineering plastics 60%

FOREIGN TRADE

Exports—easing in 1980 to less than 40 million gal; imports—easing to about 50 million gal

PRICES

Contract 62 cents per gal at plant

COMMERCIAL VALUE

$900 million for total 1980 production, $550 million in 1979

Methanol producers in 1980 will be able to sell all they can make. Production growth therefore depends on how high capacity can be operated. That may be not so high as the official figures indicate.

Producers probably will be lucky to get a 10% production increase to 1.2 billion gal in 1980 from 1.1 billion gal in 1979, despite a 15% increase in nameplate capacity to 1.55 billion gal from a year ago.

Behind the prospect of less than a 100 million gallon addition in output this year are plant operating problems, specifically, maintenance and one plant startup.

Most methanol plants except the newest one, Du Pont's facility at Deer Park, Tex., will be shut down temporarily for maintenance, including catalyst change, sometime in 1980. The downtime could range from two to four weeks each. A simple catalyst change and minor maintenance will take two weeks. If other problems are found, the downtime can stretch out rapidly. On balance, 5 to 8% of capacity probably will be out of service during 1980.

Some of the lost production will be made up once plants are restarted. Generally, the new catalyst charge allows higher initial operating rates. However, no more than half of the lost production is expected to be made up.

The other operating problem is simply the teething of Du Pont's new plant, which uses a brand new feedstock. Du Pont is now operating its new 200 million gal-per-year methanol plant, whose raw material is synthesis gas (carbon monoxide and hydrogen) produced from heavy residues of oil refineries. But the unit has had it ups and downs. Sources outside the company say the new plant will do well in 1980 to produce at half its nameplate capacity.

If Du Pont can achieve this output, the new plant would about equal total output lost from maintenance shutdowns at other plants. It would not, however, cover any demand increases during the year.

Consumption of methanol in 1980 is expected to jump in some uses and fall off in others. The star growth market, quite spectacular, will be methyl *tert*-butyl ether, the new-generation octane-boosting additive for gasoline.

MTBE took only laboratory-sized quantities of methanol in 1978, and a very small commercial amount in 1979. Now MTBE accounts for 5% of the total methanol market and will continue to expand in 1980, reaching nearly 10% by year's end, according to some forecasters. That's a rise from close to zero to an annual rate of 120 million gal of methanol in two years.

Another use of methanol that is growing in healthy jumps is acetic acid made via carboxylation. Currently, about 10% of methanol use is in acetic acid. National Distillers will start up an acetic acid plant next to Du Pont's new methanol plant later this year using the methanol as feedstock. Longer term, as natural gas becomes more expensive, and coal possibly becomes the favored feedstock for methanol, synthesis-gas-based methanol could dominate as the raw material for acetic acid.

Less robust among methanol's major uses is formaldehyde. This use of methanol likely will decline in 1980 as formaldehyde's main outlet, home construction, slows further. This forecast was made last year as well, but the effect on methanol didn't materialize.

The various other uses of methanol will decline if a moderate recession takes hold in the U.S. Use in polyester fiber, for example, may be hit hard. Polyester is now beginning to slump significantly.

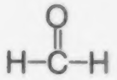
Such declines in methanol use in 1980 don't concern producers. New uses will take up any slack easily. As a result, methanol producers expect to be able to pass along their cost increases, particularly for natural gas, to buyers. Quarterly price increases may be the rule for 1980.

World prices for methanol continue to rise faster than in the U.S. The result is a continued slowing of imports to the U.S., since producers can get more for their methanol elsewhere.

However, U.S. exports probably will remain low, 3% or so of production, because U.S. demand is firm and shipping costs are high. Exports and imports are expected to nearly balance during 1980, with a small decline in both to 40 million gal and 50 million gal, respectively. No matter, since methanol has the luxury of sold-out production in the U.S. this year.

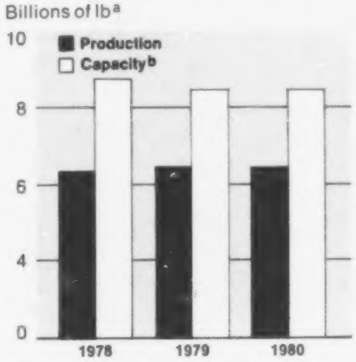
Key Chemicals

Formaldehyde


$H-C(=O)-H$

- ***Demand to soften***
- ***Capacity adequate***
- ***Prices due up***

PRODUCTION/CAPACITY



a As a 37% solution. b First quarter.

HOW MADE

Catalytic oxidation of methanol

MAJOR DERIVATIVES

Urea-formaldehyde resins 25%, phenol-formaldehyde resins 25%, polyacetal resins 5%, butanediol 5%, pentaerythritol 5%

MAJOR END USES

Adhesives 60%, plastics 10%

FOREIGN TRADE

Exports and imports negligible

PRICES

6.2 to 7.5 cents per lb as 37% solution with variations due to location, additives, and so on

COMMERCIAL VALUE

$500 million for 1980 total production, $400 million in 1979

Toxicity will be the outside event in formaldehyde news in 1980. But for the moment, toxicity will have only a minor impact on production and use. Other factors, such as the now slumping home building market, will determine the level of production.

Overall, in 1980 formaldehyde is the only one of the four natural-gas-based chemicals in C&EN's Key Chemicals series vulnerable to a decline in production. But opinion varies widely on whether such a decline will happen. A severe recession easily could cut 300 million lb or more, about 5%, from 1979 formaldehyde production of 6.5 billion lb (sold as a 37% solution in water).

However, the effect of the recession, if one is under way, hasn't been seen yet in formaldehyde. So some producers look for as much as 200 million lb of added output during 1980.

No problem exists with capacity to make formaldehyde, which includes a large number of plants scattered through regions where wood is processed into plywood and particleboard. These two end products use formaldehyde in adhesive resins. If formaldehyde production in 1980 reaches 6.5 billion lb, plant use will be about 77% of an unchanged 8.5 billion lb of nameplate capacity. This level is considered typical for a product subject to seasonal variations in end uses.

Resins classed as adhesives account for about half of formaldehyde use, but a significant part of these resins goes to uses other than binding wood sheet or particles together. For example, about 15% of urea-formaldehyde resins, the largest single use of formaldehyde, goes into nonwood uses such as paper coatings or additives for paper and textiles. However, these smaller uses are not growing much, if at all, and so have little impact on the outlook for formaldehyde.

The fraction of phenol-formaldehyde resins that goes to nonwood binding uses is much larger than that for urea-formaldehyde resins, whose end use pattern is narrower. But again, these uses don't seem to have very large growth rates and likely will make only small increases in formaldehyde use.

Formaldehyde's large use in wood products has led to concern over its toxicity. Apparent depolymerization of the resins used in plywood and particleboard in some cases has released formaldehyde, the odor of which was noticeable in household interiors and mobile homes. Then came concern over plant workers who might have contact with formaldehyde or with its derivatives.

Toxicity research on formaldehyde has expanded rapidly over the past year. The Formaldehyde Institute, an association of producers, is sponsoring the work, as are various other groups. As yet a consistent, broad pattern of results has not developed. When enough information becomes available, and if toxicity is reasonably shown, formaldehyde could face a drastic exposure-control campaign much like the severe (and successful) clampdown on vinyl chloride in the mid-1970's. However, formaldehyde could have a rougher road because of the more fragmented nature of its production and use.

The toxicity hurdle is not expected to affect demand for derivatives of formaldehyde significantly. Formaldehyde is a very cheap material to make, with little competition, but production costs may well increase.

Consumers of products made using formaldehyde continue to fool demand forecasters. Housing has turned down but not as much as many forecasters expected. Automobile sales are off, reducing demand for derivative polyacetal resins in their largest use. However, weight-saving efforts partly offset this decline by allowing greater use per car.

Even if demand for formaldehyde declines 5% in 1980, prices hardly will be affected. Most of formaldehyde's cost comes from raw material methanol. As a result, formaldehyde prices are closedly tied to methanol's, which means to the price of raw material natural gas.

Formaldehyde prices, however, are a relatively small part of the cost of derivatives and end products, making formaldehyde's cost minor in the total end-use picture. Formaldehyde's insignificance in end-product costs may shield it from the worst in a weak housing year. Still, the product cannot hope for much more than a flat year in physical volume and may have a weighty challenge to deal with in toxicity.

Chemical & Engineering NEWS

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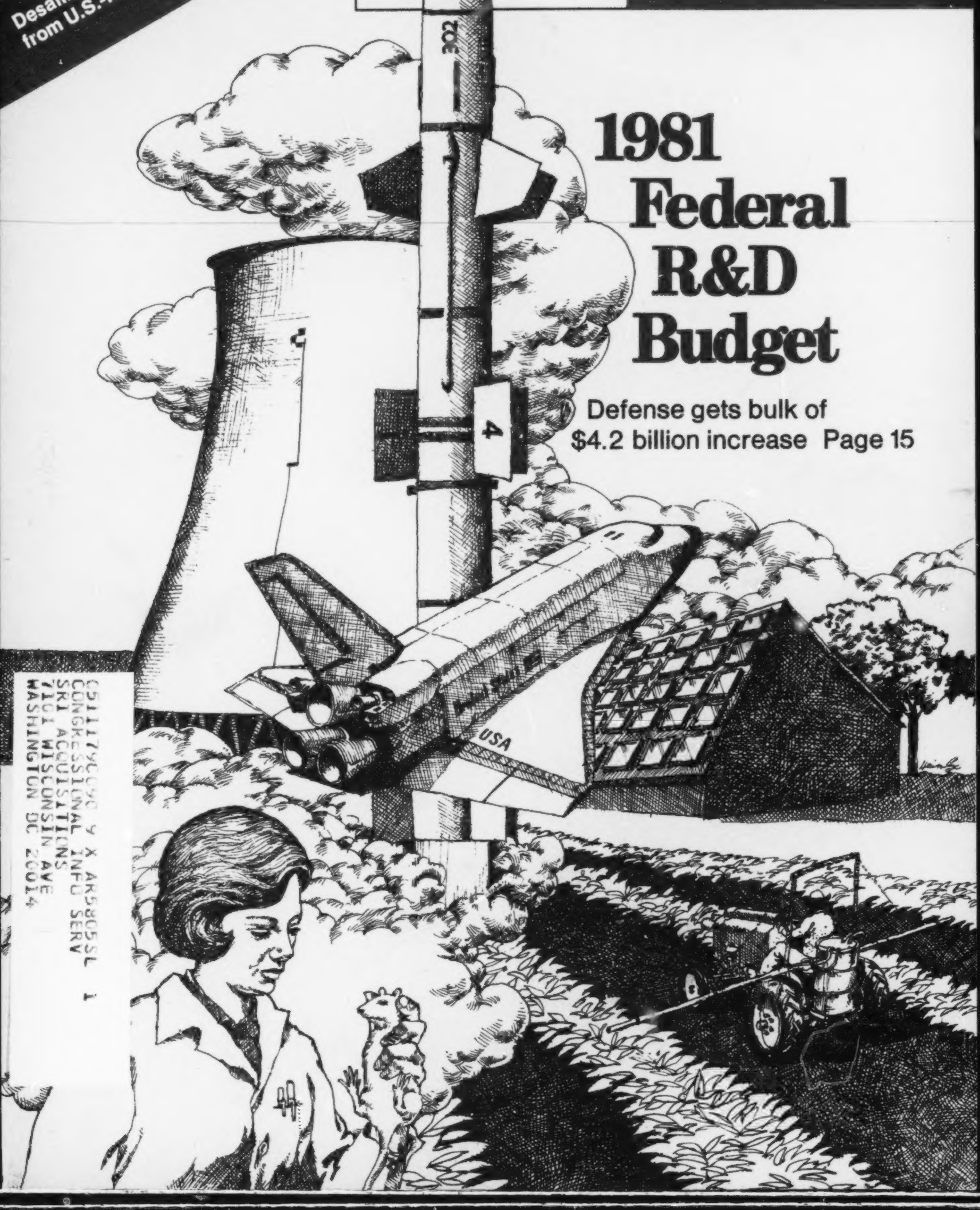

1981 Federal R&D Budget

Defense gets bulk of $4.2 billion increase Page 15

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- ***Reactions to exile of Soviet scientist*** *Andrei Sakharov include protests from many organizations suggesting a boycott of U.S.-U.S.S.R. scientific exchanges.* ***Page 6***
- ***Atherosclerosis linked to herpesvirus*** *infection of the arterial cell wall in studies done on chickens fed cholesterol-free and cholesterol-supplemented diets.* ***Page 7***
- ***Revisions relaxing NIH guidelines*** *for recombinant DNA research, which went into effect last month, met little opposition from the academic community.* ***Page 7***
- ***Production of liquid hydrocarbon fuels*** *from coal at Exxon Research & Engineering's Baytown, Tex., pilot plant is expected to start this spring.* ***Page 7***
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Brazil seeks self-sufficiency in styrene

With demand to hit 375,000 metric tons by 1985, Brazil plans to hike capacity for monomer substantially, cut down dependence on imports

Brazil is working hard to get its styrene house in order.

Styrene demand this year probably will reach 200,000 metric tons, up 105% from what it was in 1974. And, with demand expected to rise to 375,000 metric tons by 1985, Brazil is putting in huge new chunks of styrene capacity and adding new plants to produce ethylbenzene, styrene's raw material.

Behind the country's capacity buildup is its desire to cut down on imports and become self-sufficient in styrene and ethylbenzene.

Until late 1977, Cia. Brasileira de Estireno (Brazilian Styrene) was the country's only styrene producer. But the firm's 70,000 metric-ton-per-year plant at São Paulo couldn't come close to meeting demand. In 1976, Brazilian Styrene produced 62,000 metric tons and in 1977 64,000 metric tons. But Brazil still had to import 65,000 metric tons in 1976 and 50,000 metric tons the next year to meet the country's thirst for styrene.

In December 1977, Petroflex Ind. e Comércio put its 60,000 metric-ton-per-year styrene unit on stream near Rio de Janeiro, but it couldn't contribute anything to Brazil's styrene production until the following year. Meanwhile, in 1978, Estireno do Nordeste (Northeast Styrene) also put on stream its huge 100,000 metric-ton-per-year styrene unit at Brazil's mammoth Second Petrochemical Pole in Camacari, Bahia.

With Petroflex on stream for the full year and Northeast Styrene on stream for at least part of the year, styrene production jumped to 145,000 metric tons in 1978, more than double what it was the year before. Styrene imports dropped to 10,000 metric tons in 1978, compared to 50,000 metric tons in 1977. And Brazil even managed to export 8000 metric tons of styrene.

Last year, Brazil produced about 176,000 metric tons of its own styrene. That's almost 20% more than the year before, but still only a relatively low 76% of its installed nameplate capacity.

But last year wasn't a smooth one for Brazil's three styrene producers. Operating problems plagued some plants. And, with benzene supply tight last year, producers couldn't get all of the benzene they wanted to operate their ethylbenzene units.

As a result, Brazil wasn't able to eliminate completely its need to import styrene. Last year, an estimated 6000 metric tons of styrene was shipped into the country, not much less than in 1978 before Northeast Styrene's 100,000-metric-ton plant became fully effective.

Actually, Brazil probably won't eliminate styrene imports completely, at least for several more years. Several polystyrene producers have government permission to import small amounts of styrene under a drawback arrangement.

But, faced with a styrene demand that is expected to grow 11% per year over the next five years, Brazil fully intends to keep styrene imports as low as possible. Another huge styrene unit already is in the works.

This will be a 125,000 metric-ton-per-year unit that will be built by Oxiteno do Sul as part of Brazil's Third Petrochemical Pole being constructed at Rio Grande do Sul in southern Brazil. Oxiteno's plant will produce styrene along with 50,000 metric tons per year of propylene oxide using Oxirane technology.

For Oxiteno, this will be its first venture into styrene. The company's expertise lies in ethylene oxide, various glycols, and ethers. Several other companies would have liked to build Brazil's next styrene plant, among them Brazilian Styrene and Dow Chemical, which produces polystyrene there. But in Brazil, the government calls the shots and it opted for Oxirane's proposal, presumably because it filled a need for both styrene and propylene oxide.

The Oxiteno unit originally was scheduled to come on stream in 1982. Now, it has been delayed until 1985. If, indeed, the plant isn't operating until 1985, Brazil will be forced to start importing large volumes of styrene again in 1982. Capacity will remain at 230,000 metric tons, but demand in 1982 probably will be about 260,000 metric tons.

And even with the Oxiteno unit on stream, Brazil will need more styrene capacity by 1985. Demand by then will reach 375,000 metric tons and capacity, even with the Oxiteno unit, will only be 355,000 metric tons. There seems little doubt that styrene plant expansions or another new unit is in the cards for Brazil.

The only benefit to come from the delay in building Oxiteno's plant will be a temporary solution to Brazil's ethylbenzene problem. Until 1978, Brazilian Styrene was the country's only ethylbenzene producer. It supplied almost all—but not completely

Brazilian styrene capacity is growing . . .

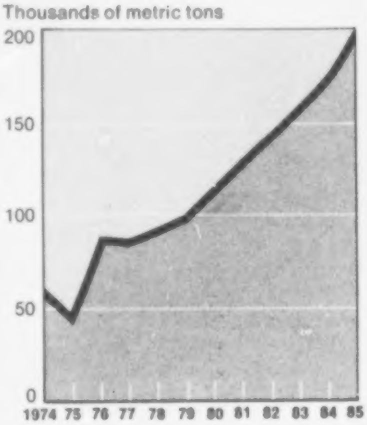
Thousands of metric tons	1976	1977	1978	1979	1980	1981	1982
Cia. Brasileira de Estireno	70	70	70	70	70	70	70
Petroflex Ind. e Comércio		60	60	60	60	60	60
Estireno do Nordeste			100	100	100	100	100
Oxiteno do Sul							125[a]
TOTAL	70	130	230	230	230	230	355

. . . while ethylbenzene capacity tries to keep pace

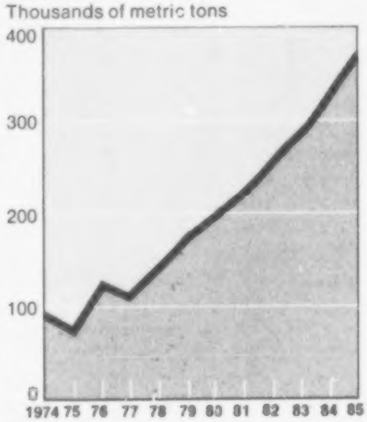
Thousands of metric tons	1976	1977	1978	1979	1980	1981	1982
Cia. Brasileira de Estireno	70	70	70	70	70	70	70
Estireno do Nordeste			110	110	110	110	110
Petroflex Ind. e Comércio							150
TOTAL	70	70	180	180	180	180	330

a May be delayed until 1985. **Source:** Associacão Brasileira da Industria e de Produtos Derivados (Abiquim)

Brazilian polystyrene demand . . .



. . . will help spur increased use of styrene



Sources: 1974–78, Abiquim (Associacão Brasileira da Indústria Quimica e de Produtos Derivados); 1979–85, C&EN estimates

all—of its own ethylbenzene requirements.

Petroflex has no captive ethylbenzene. Northeast Styrene has a 110,000 metric-ton-per-year ethylbenzene unit to go along with its styrene plant at Camacari. Last year, Northeast Styrene was able to supply some of Petroflex' ethylbenzene, but an estimated 40,000 metric tons of the raw material still had to be imported.

In 1982, Petroflex is scheduled to put on stream a 150,000-metric-ton ethylbenzene unit at Rio Grande do Sul. This was to supply Oxiteno's styrene-propylene oxide plant. But, if Oxiteno delays its plant until 1985, the Petroflex ethylbenzene unit will be able to supply its own requirements at Rio, at least for a few years. After that, Brazil will be looking for more ethylbenzene capacity to go along with its styrene.

Earl Anderson, C&EN New York

CHECKOFF

NEW PLANTS

■ **Canada**—Cyanamid Americas/Far East part of American Cyanamid plans $19 million, 50,000 metric-ton-per-year calcium carbide expansion at Niagara Falls, Ont., to be completed in 1981, doubling capacity. Product will go to steel industry in desulfurizing reagents.

■ **Chile**—Empresa Nacional de Explosivos S.A. of Santiago has awarded contract to Davy International, West German unit of Davy Corp. of U.K., and to Ingeniera y Construccion Sigdo Koppers of Chile for $25 million, 150 metric-ton-per-day (54,800 metric tons per year) ammonium nitrate plant at Mejelliones on north coast. Startup is planned for beginning of 1982.

■ **Finland**—Kemira Oy of Helsinki has ordered fourth nitric acid plant at Uusikaupunki on Baltic Coast from Uhde GmbH, part of West Germany's Hoechst; capacity will be 400 metric tons per day (146,000 metric tons per year) using Uhde medium-pressure process. On-stream target date is third-quarter 1981.

■ **France**—Du Pont has purchased 37-acre site in Besançon, about 30 miles from Swiss border, for more than $20 million investment, including plant to produce Berg electrical-electronic connectors for data processing and other markets; completion expected in 1981.

■ **Japan**—Sumitomo Chemical is building plant at Chiba complex for 5000 metric tons per year (11 million lb per year) of resorcinol and 2000 metric tons per year (4.4 million lb per year) of hydroquinone; completion targeted for fall 1980. Technology will be new hydroperoxide process based on benzene and propylene.

■ **Portugal**—Uhde GmbH of West Germany has contract to build two 360 metric-ton-per-day (131,400 metric tons per year) nitric acid plants for Messrs. Quimigal of Lisbon, state-owned chemical producer, at Alverca and Lavradio near Lisbon. Plants will use Uhde's dual-pressure process.

■ **South Africa**—Fluor will take part in $30 million contract to build plant to convert creosote-rich coal tars into transport fuels for Sasol Three (Pty.) Ltd. at Secunda in eastern Transvaal. Fuel capacity will be 8000 bbl per day at Sasol Two and Three coal-to-liquids complexes that Fluor is building. Creosote plant will be first of its kind, a type which could be used in U.S., says Fluor. Completion scheduled for mid-1982.

■ **West Germany**—W. R. Grace is building paper chemicals plant in Worms to come on stream at end of third-quarter 1980. Specialty products will include wet-strength resins and synthetic surface and bulk sizing materials. Company also has initial plans without further detail for European facility to produce fluid-cracking catalysts for oil refineries worldwide.

PLANTS COMPLETED

■ **Colombia**—PQ Corp.'s Colombian affiliate, Productos Quimicos Panamericanos of Medellin, has brought on stream second aluminum sulfate plant in Barranquilla, increasing capacity there to 40,000 metric tons per year.

■ **India**—Montedison's engineering arm, Tecnimont, has started up 1000 metric-ton-per-day (365,000 metric tons per year) urea plant in Sindri, about 140 miles northwest of Calcutta. Plant owner is Fertilizer Corp. of India.

■ **Norway**—Norpolefin's new 60,000 metric-ton-per-year (132 million lb per year) high-density polyethylene plant at Bamble started up successfully in second half of 1979, says Saga Petrokjemi, which manages plant. First HDPE plant in Norway, Bamble unit uses Phillips Petroleum technology to make resin from ethylene derived from natural gas liquids from North Sea.

■ **U.K.**—British Industrial Plastics, part of Turner & Newall, has completed 50,000 metric-ton-per-year (110 million lb per year) polyvinyl chloride suspension resin plant at Aycliffe in northern England. Technology is on license from B. F. Goodrich.

R&D spending rise outpaces that of total federal budget

Spending for R&D activities would be up 13%, for basic research up 12% in a fiscal 1981 federal budget that would rise only 9% overall

Janice R. Long, Lois R. Ember, and David J. Hanson
C&EN, Washington

"Austere, prudent, responsible, restrained" were the words being used by federal officials to describe the fiscal 1981 budget proposal unveiled late last month. But for once a tight federal budget doesn't mean bad news for the research community. Instead, the budget proposal bears out President Carter's oft-repeated message of support for science and technology.

Federal outlays are expected to rise only 9% to $615.8 billion. Inasmuch as the Administration is predicting a 9% inflation rate in fiscal 1981, the budget is virtually level with fiscal 1980 spending. The deficit would be held to $15.8 billion, the lowest level in seven years.

Total federal R&D obligations, however, would be up 13%, or $4.2 billion, to $36.1 billion and outlays would be up 11% or $3.2 billion, to $33.7 billion. Both would at least keep up with inflation and the Administration predicts that the increases will allow for real growth. The largest increases are slated for the Department of Defense, 21%, and the National Science Foundation, 17%.

Following the trend in recent years, basic research will continue to do quite well. Under the proposed budget, basic research obligations would be up 12% to $5.1 billion, following a 10% rise in fiscal 1980. Outlays would rise 11.8%, the same rate as in fiscal 1980, to $4.7 billion. Between 1978 and 1981 the basic research budget will have risen some 40%, according to Administration figures, allowing 9% real growth.

Not quite keeping up with the overall rise in federal R&D obligations is R&D support for colleges and universities, which is budgeted to rise 9.5%, or $397 million, to $4.6 billion. About 50% of these funds would go for basic research, about one third for applied research (primarily medical), and the remainder for development activities. And Presidential Science Adviser Frank Press believes that this figure is a bit low—he expects an increase closer to 12%—because of underestimated spending by the Department of Defense for new university research programs. Budget documents show an increase of 10% in DOD's support of university research; Press says the increase will be closer to 25%.

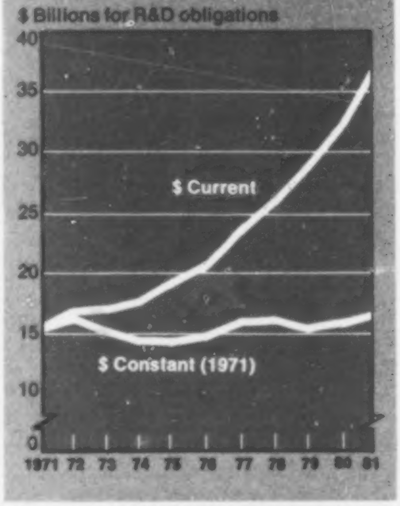
Going counter to the upward trend, obligations for constructing or renovating R&D facilities, acquiring major equipment items, and building and operating demonstration plants would decrease slightly—$23 million, or 1.6%—to about $2 billion. This decrease is perhaps partly explained by the 43.7% increase in obligations for this category in fiscal 1980.

A breakdown of R&D funding by agency finds DOD with about the same large slice of the federal R&D pie as in previous years, 46%. However, DOD's R&D obligations are scheduled to rise a whopping 21%, or $2.9 billion, to a total of $16.6 billion in fiscal 1981. Still the research, development, testing, and evaluation budget proposed for 1981 would amount to only 10.4% of the entire DOD budget, a slight increase from last year. Basic research funding by DOD also would rise more than 20%, up $92 million to $523 million.

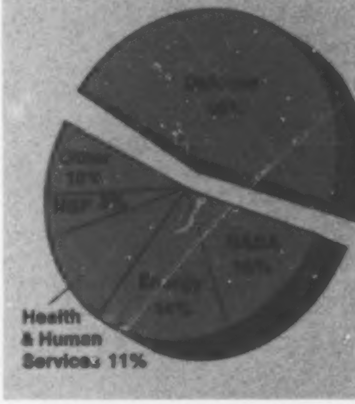
According to DOD, this substantial growth in R&D funding would both provide for choices in future weapons systems development and give it the capability to avoid any technological surprises. Areas to be emphasized in 1981 include materials research, environmental research, behavioral research relevant to combat, and high-energy lasers and particle beams as potential weapons.

The largest single DOD R&D obligation would go to the multiple-warhead, long-range M-X missile, whose funding would increase 131% to more than $1.5 billion to provide for full development of the system.

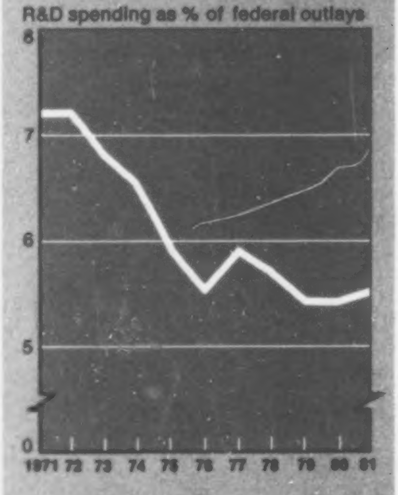
R&D funds grew only 13% in constant dollars since 1971



Greatest emphasis is on defense R&D



R&D funding holds steady at 5.5% of federal budget



C&EN staff photo

OMB director James McIntyre looks over budget at Government Printing Office

Glossary of budget terms

Authority. Permission to incur obligations, requiring either immediate or future payment, which will become available during the year. Appropriations on which Congress acts are the most common form of budget authority, allowing federal agencies to make payments out of the Treasury for specified purposes.

Deferral. Any executive branch action or inaction that delays the availability of budget authority for obligations. Deferrals may not extend beyond the end of the fiscal year and may be overturned at any time by either branch of Congress.

Fiscal year. Year running from Oct. 1 to Sept. 30. The fiscal year is designated by the calendar year in which it ends.

Obligations. Commitments made by federal agencies to pay out money for products, services, or other purposes, as distinct from the actual payments.

Outlays. Payments for obligations incurred under budget authority, generally made by issuance of checks by Treasury. Outlays during any fiscal year may be payments of obligations incurred in prior fiscal years or in the same fiscal year.

Recission. Enacted legislation canceling budget authority previously granted by Congress. Recissions proposed by the President must be approved by Congress within 45 days to become effective.

Other major projects involve developing antisatellite capabilities, antitank guided missiles, airfield attack and armor attack munitions, and communications and intelligence support for weapons systems.

Funding for some specific items in the DOD R&D budget includes $72 million for research on high-energy lasers, $52 million for materials research, about $45 million for chemical weapons defenses, almost $20 million for environmental quality research, and $5 million for drug and vaccine development.

The defense activities of the Department of Energy also are budgeted for a sizable increase in fiscal 1981. Although DOE's overall budget is slated for an increase of 7.6%, or $979 million, to $12.7 billion, its budget for defense activities would be up 14.5%, or $435 million, to $3.4 billion. The only program areas with an increase of less than 9% are inertial confinement fusion, funding for which would be up only 3.6% to $202 million, and materials production, whose funding would be up 2% to $522.5 million.

Some programs are in for quite large increases. For example, defense waste (i.e., nuclear) management funding would increase 23% to $349.7 million and the weapons program budget would rise 19%, to $2 billion, with the largest part of the increase, 71%, going for weapons production and surveillance.

DOE's civilian R&D program did not fare so well as its defense program. The agency's funding authorities (which are equivalent to other agencies' obligations) for civilian R&D programs are budgeted to increase only $118.3 million, or 3%, to $4.2 billion. Outlays would decrease $4.6 million, a scant 0.1%, to $4.2 billion.

But although the budget would stay fairly constant, there are a number of increases and decreases in funding for various DOE R&D programs. The major decrease is for DOE's nuclear programs, which would be cut 28%, or $305 million, to $768.2 million. Cuts of $377.6 million in the breeder reactor and $11 million in the convertor reactor budgets are slightly offset by increases of $78 million for the commercial waste management program and of $4.6 million for advanced nuclear systems. The only other decrease scheduled in the DOE budget is a relatively minor one for conservation R&D funding, which would be down 5.3% to $269.5 million.

The fossil energy budget, on the other hand, is a big winner. After having been cut about 3% in fiscal 1980, it is scheduled for a 31% increase in fiscal 1981, to $1.1 billion—perhaps a reflection of the new emphasis on synthetic fuels. The fossil energy budget provides for, among other things, $23 million to continue development of atmospheric fluidized-bed combustion systems, $97 million to continue R&D on technologies to increase energy conversion efficiency in fuel cells and magnetohydrodynamics, and $65 million for basic research on and development of advanced coal conversion technologies.

The other DOE R&D programs are scheduled for increases ranging from a modest 1% for solar energy technology to 13.4% for basic energy sciences. The proposed authorities of $257.3 billion for the basic energy sciences program include $74.4 million for chemical sciences, an increase of 14.5% over fiscal 1980 levels. Chemical sciences initiatives include solar photoconversion, catalysis, and combustion research.

The National Aeronautics & Space Administration once again would become the largest federal spender of civilian R&D dollars in 1981, after being surpassed briefly by the Department of Energy in 1980. Under the budget proposal, funds for conducting R&D would be up $463 million, or 11.3%, to $4.6 billion. NASA's total budget would be up 9% to $5.7 billion.

The largest item in NASA's R&D budget is, of course, the space shuttle. Funded at just under $1.9 billion for 1981, it is the largest single R&D project in the entire U.S. budget. The 1981 funding would support the initial manned orbital flight of the shuttle, now expected in late 1980 and a shuttle production schedule that could meet civilian and military launch requirements.

The 1981 budget also includes funds for three new projects. One of these is a gamma-ray observatory, scheduled to be launched in 1985. The observatory, with first-year funding of $19 million, is expected to increase significantly basic knowledge of phenomena such as quasars and black holes by studying their gamma-ray emissions.

The other new projects are an operational land observing system, funded at $16 million, and a national oceanic satellite system, to be developed jointly by the National Oceanic & Atmospheric Administration and DOD to obtain oceanic data by remote sensing from space. First-year funding for this project is set at about $6 million.

Development is continuing on projects approved in previous years. The most important is the space telescope, with funding increased almost 6% to $119 million. The telescope will be able to observe objects as far away as 60 billion light years from Earth without the obscuring effects of Earth's atmosphere. Also, the international solar polar project would get a big boost with a proposed 72% increase in funding for 1981, to about $83 million. This project, expected to launch in 1983, will be the first ever to study the sun's polar regions. Finally, the Galileo mission to Jupiter has been restructured as a dual shuttle project planned for launch sometime in 1984. Its funding would be cut almost in half for 1981, to $63 million.

In aeronautics research, programs would continue to develop greater fuel efficiency, safety, and reduced noise for aircraft. New initiatives are being proposed for advance turboprop technology that has the potential of increasing fuel efficiency more than 20% over current designs.

The 1981 budget for the Department of Health & Human Services (formerly part of Health, Education & Welfare) is slated to increase 6% over fiscal 1980 obligations to a total of $4.0 billion. Of this, $1.8 billion would be for basic research.

Quite a hefty portion of the $4.0 billion, however, would go to the National Institutes of Health to support a wide range of biomedical and behavioral research. NIH's 1981 R&D budget of $3.7 billion, up from $3.6 billion in 1980, would focus on basic and applied research in nutrition, genetics, diabetes, radiation and other environmental hazards, aging, and senile dementia.

Included in NIH's budget request are sufficient funds, HHS says, to ensure the continuity of national biomedical research by stabilizing at 5000 the number of new and competing research grants to individual researchers or teams. Also included in the 1981 NIH budget is $92 million to expand the National Toxicology Program, headed by David Rall, director of the National Institute of Environmental Health Sciences.

Among NIH research efforts to be supported in fiscal 1981 are studies to elucidate the role of nutrition in cancer, cardiovascular disease, childhood development, and aging; research into the causes, treatments, and prevention of diabetes; and research on tropical diseases, a new thrust for NIH.

HHS R&D funds also are distributed to, among others, the Food & Drug Administration, the Center for Disease Control, and the National Institute for Occupational Safety & Health. FDA's fiscal 1981 budget of $362 million, an increase of $34 million over fiscal 1980, includes $25 million to build new laboratory facilities for the Bureau of Foods and the Bureau of Drugs. FDA's R&D funds of $67 million in fiscal 1981 will go toward research in support of its regulatory responsibilities, including research on the biological effects of toxic substances at its National Center for Toxicological Research.

The Center for Disease Control, charged with health protection and disease prevention, has fiscal 1981 obligations proposed at $391 million, up $25 million over fiscal 1980. About $31 million would go into coordinating responses to state requests for help in bringing environmental emergencies, such as Love Canal and Three Mile Island, under control and in studying their effects on human health.

A small part of the center's R&D obligations of $95 million for fiscal 1981 would be devoted to research on health services, health statistics, and health-care technology assessments. Nevertheless, fully 87% of its R&D budget is slated for research undertaken by the National Institute for Occupational Safety & Health to develop criteria on toxic materials and other occupational hazards. A prime NIOSH thrust is planned for basic research in occupational safety and health.

National Science Foundation officials are once again more than satisfied with the President's budget request. Not only would NSF's total budget be up more than 15% to $1.1 billion, but its research and related activities budget would pass the billion-dollar mark for the first time, riding a 17.7%, $159 million increase. Obligations for NSF science education programs would be up almost 10%, or $7.5 million, to $85.7 million.

The budget proposal shows that NSF will be playing a major role in the Administration's efforts to stimulate industrial innovation. Funding for NSF's industry/university cooperative research program would be up a whopping 185% to $20 million. And funding aimed at stimulating small business innovation and industrial technology would rise 147% to $18.2 million, with $13 million targeted for highly innovative research in small businesses.

A new effort by NSF in fiscal 1981 would be a $14.3 million program to upgrade university research laboratories, many of which have outdated facilities. This is planned as a matching grant program, with academic institutions matching federal funds from nonfederal sources. NSF also plans to initiate a 10-year, estimated $700 million ocean margin drilling program intended to produce geological, geophysical, and other information. The program would be funded jointly by industry and government.

Basic research funding up 12% to $5 billion

$ Millions	1981[a]	1980[a]	% change 1980-81
Health & Human Services	$1840	$1728	6.5%
NSF	952	814	16.9
Energy	593	523	13.4
NASA	581	535	8.6
Defense	523	431	21.3
Agriculture	324	289	12.1
Interior	78	76	2.6
Smithsonian	44	39	12.8
Commerce	36	28	28.6
Education	25	20	25.0
EPA	19	14	35.7
Others	58	32	81.2
TOTAL	$5073	$4529	12.0%

a Estimates. **Note:** Obligations.

But the new initiatives don't mean that the budget request has slighted any of NSF's ongoing programs. Obligations for basic research, which accounts for 83% of NSF's efforts, would be up 17% to $951.5 million. Obligations for applied research would increase more than 25% to $93.4 million. Although funding for all the directorates would increase at least 9%, the largest increase would be for the engineering and applied sciences directorate, whose budget would rise 22% to $137 million. Funding for chemical and process engineering is slated for a 20% increase to $16.7 million.

The mathematical and physical sciences directorate would get the next largest increase, 16.7%, with obligations budgeted to rise to $264.2 million. The directorate would, among other things, support frontier research in chemistry, materials research, and computer science related

Defense R&D funds soar with 20% increase

$ Millions	1981[a]	1980[a]	1979[b]
Tactical programs	$5,715	$5,371	$4,984
Strategic programs	3,267	2,231	2,078
Technology base	2,656	2,150	1,976
Program management and support	2,254	1,788	1,693
Intelligence and communication	1,530	1,114	748
Advanced technology development	612	619	542
Other	532	508	441
TOTAL	$16,566	$13,781	$12,462

a Estimates. b Actual.

The total federal R&D package

Agency by agency R&D funding breaks down like this

$ Millions	Obligations 1981^a	Obligations 1980^a	Obligations 1979^b	Outlays 1981^a	Outlays 1980^a	Outlays 1979^b
Defense	$16,565	$13,781	$12,463	$15,169	$13,253	$11,454
NASA	5,617	5,114	4,411	5,277	4,858	4,064
Energy	5,106	4,919	4,588	5,068	4,871	4,413
Health & Human Services	4,011	3,784	3,485	3,661	3,428	3,068
NSF	1,056	897	805	964	853	775
USDA	786	743	670	670	652	611
EPA	445	415	410	413	384	337
Interior	415	419	405	413	396	393
Labor	385	279	137	374	277	102
Transportation	379	353	357	346	332	340
Commerce	379	371	334	394	347	305
NRC	228	204	157	204	182	141
Education	156	146	164	154	151	128
Veterans Adm.	142	134	130	135	126	117
Other	465	397	368	456	368	331
TOTAL	$36,135	$31,956	$28,884	$33,720	$30,478	$26,579

a Estimates. b Actual.

Federal R&D funds to universities would jump about 10%

$ Millions	Obligations 1981^a	Obligations 1980^a	Obligations 1979^b	Outlays 1981^a	Outlays 1980^a	Outlays 1979^b
Health & Human Services	$2244	$2097	$1932	$2075	$1896	$1691
NSF	794	670	602	725	637	580
Defense	443	401	364	416	376	341
Energy	364	323	292	361	320	281
USDA	236	223	206	215	194	169
NASA	174	163	144	157	147	127
Other	335	316	292	296	257	243
TOTAL	$4590	$4193	$3832	$4245	$3827	$3432

a Estimates. b Actual.

Funding for R&D facilities would fall slightly

$ Millions	Obligations 1981^a	Obligations 1980^a	Obligations 1979^b	Outlays 1981^a	Outlays 1980^a	Outlays 1979^b
Energy	$1257	$1309	$822	$1179	$1032	$690
Defense	445	369	270	383	306	236
NASA	120	156	148	163	155	133
Health & Human Services	47	46	51	42	66	74
USDA	37	38	23	42	36	22
Other	93	113	99	98	134	100
TOTAL	$1999	$2031	$1413	$1907	$1729	$1255

a Estimates. b Actual.

to microstructures; increase support for the Materials Research Laboratories by $2.8 million to $22.2 million; and increase support for research project instrumentation, including chemistry department equipment, $5 million to a total of $26.2 million.

Obligations for chemical research would climb 15.8% to $59.5 million. The $8 million increase is spread fairly evenly among all the chemistry program areas, with funding in each increasing 14 to 16%.

Research funding would be up this year at the Department of Agriculture, too, 5.8% from $743 million in 1980 to $786 million in 1981. About 75% of the $43 million is earmarked for basic research, including expansion of agriculture and resource surveys through satellite remote sensing.

The Agricultural Research and Cooperative Research programs of USDA's Science & Education Administration combined would get 77%, or about $606 million, of the department's R&D funds. Agricultural Research projects, funded at $403 million, would emphasize integrated pest management, human nutrition and health, aerospace technology, and basic research related to food production.

Cooperative Research programs would receive an additional $13 million for 1981, for total funding of $203 million. This program administers funds for the state agriculture experiment stations and other institutions doing comparable research. It also would receive a very large increase for its competitive grants project, 56%, raising it to $25 million. This project funds basic research in such areas as nitrogen fixation and the ability of humans to utilize vitamins and minerals.

Also, legislation has been proposed to authorize $50 million for improvement of research facilities at the predominately black 1890 colleges (established that year to aid blacks) and Tuskegee Institute. The 1981 funding includes $5 million for the federal portion of the first year of this proposed five-year program. State governments would be required to provide funds matching the federal payment.

EPA is swamped with work and its budget is lean, says William Drayton Jr., assistant administrator for planning and management. And in fiscal 1981 the agency will be writing and enforcing regulations for hazardous wastes under the Resource Conservation & Recovery Act, for synthetic fuel production, and for hazardous waste cleanup under superfund legislation now pending in Congress.

To perform the R&D undergirding the standards and regulations, EPA would obligate $445 million in 1981, up a mere 6.7% from 1980. The major growth areas have shifted to two chemical control programs—hazardous waste and toxic substances R&D. Funding for the hazardous waste research program would increase a whopping 86% in 1981 to $26 million, and toxic substances research funding would rise 32% to $47 million in 1981.

The largest single R&D program in EPA, however, is energy. This research effort, which would be funded at $108 million, a 6% increase, in 1981, would focus on improving the standards-setting data for synthetic fuel installations.

Of the remaining major research efforts, air research would receive $70 million, up 5%, and water-quality re-

How the agencies fare

NSF budget posts a 15.5% gain to well over billion-dollar mark . . .

$ Millions	1981^a	1980^a	1979^b
Mathematical and physical sciences	$264.2	$226.4	$208.9
Astronomical, atmospheric, earth, and ocean sciences	241.3	217.9	211.6
Biological, behavioral, and social sciences	182.0	166.5	154.7
Engineering and applied science	137.0	111.8	108.9
Science education	85.7	78.2	80.0
Antarctic program	63.4	55.8	51.1
Program development and management	60.8	60.6	54.7
Cross directorate programs	52.0	25.5	16.8
Scientific, technological, and international affairs	28.8	26.1	23.6
Ocean drilling programs	27.3	19.5	11.6
Special foreign currency program	5.5	5.5	4.0
TOTAL	$1149.0	$993.8	$926.9

a Estimate. b Actual. Note: Obligations.

. . . with funding for chemical research up 16% to almost $60 million

$ Millions	1981^a	1980^a	1979^b	% change 1980–81
Materials research	$78.6	$68.5	$62.4	14.7%
Ocean sciences	76.0	66.6	62.4	14.1
Physiology, cellular and molecular biology	74.8	67.2	62.3	11.3
Applied sciences	74.4	59.3	61.0	25.5
Physics	73.5	63.4	61.7	15.9
Atmospheric sciences	71.1	63.2	59.1	12.5
Engineering	62.6	52.5	48.9	19.2
Astronomical sciences	60.2	57.0	59.2	5.6
Chemistry	59.5	51.4	45.2	15.8
Environmental biology	40.7	37.7	33.9	8.0
Behavioral and neural sciences	38.7	35.4	33.1	9.3
Mathematical sciences	29.3	24.9	22.8	17.7
Earth sciences	27.9	25.3	24.9	10.3
Social and economic sciences	27.8	26.2	25.4	6.1
Computer research	23.3	18.3	18.8	28.0
TOTAL	$818.4	$716.8	$679.1	14.2%

a Estimate. b Actual. Note: Obligations.

NSF funding for chemical research is broken down like this

$ Millions	1981^a	1980^a	1979^b
Structural chemistry and chemical thermodynamics	$12.37	$10.66	$9.44
Chemical dynamics	11.50	9.93	8.47
Quantum chemistry	9.58	8.32	7.40
Synthetic organic and natural products chemistry	7.14	6.16	5.56
Chemical analysis	6.65	5.78	5.14
Synthetic inorganic and organometallic chemistry	6.62	5.81	5.16
Chemical instrumentation	5.57	4.76	4.07
TOTAL	$59.44	$51.42	$45.24

a Estimates. b Actual. Note: Obligations.

EPA's 1981 R&D budget increases 8%

$ Millions	1981^a	1980^a	1979^b
Energy	$107.6	$101.4	$112.6
Air	70.2	66.6	52.0
Water quality	60.0	65.2	65.7
Toxic substances	36.9	27.9	16.8
Drinking water	27.5	22.8	17.6
Solid/hazardous waste	26.4	14.2	8.5
Interdisciplinary	22.8	22.7	18.7
Pesticides	9.4	13.0	12.7
Program management	4.7	4.6	4.4
Radiation	3.2	3.1	1.8
TOTAL	$368.7	$341.7	$311.8

a Estimates. b Actual. Note: Obligations.

NASA's R&D budget rises a solid 11%

$ Millions	1981^a	1980^a	1979^b
Conduct of R&D	$4571	$4108	$3477
Space shuttle	1873	1886^c	1638
Space flight operations	810	447	300
Physics and astronomy	439	337	283
Space applications	382	332	275
Space tracking and data systems	359	332	300
Astronautical research and technology	290	308	264
Planetary exploration	180	220	182
Space research and technology	115	116	107
Expendable launch vehicles	56	71	74
Life sciences	50	44	40
Technology utilization	13	12	9
Energy technology	4	3	5
Research and program management	1047	1006^d	934
Construction of facilities	120	156	148
TOTAL	$5738	$5270	$4559

a Estimates. b Actual. c Includes proposed supplement of $300 million. d Includes proposed supplement of $46.3 million to cover 1979 salary increases. Note: Obligations.

NIH total funds increase a modest 3%

$ Millions	1981^a	1980^a	1979^b
National Institutes	$3315	$3199	$2934
Cancer	1008	1004	936
Heart, Lung & Blood	548	529	510
Arthritis, Metabolism & Digestive Diseases	366	343	303
General Medical Sciences	332	313	277
Neurological & Communicative Disorders & Stroke	250	243	212
Allergy & Infectious Diseases	226	217	192
Child Health & Human Development	218	210	197
Eye	117	113	105
Environmental Health Sciences	102	88	81
Aging	75	70	56
Dental Research	71	69	65
Research resources	190	175	159
National Institute for Occupational Safety & Health	83	81	57
National Library of Medicine	47	47	41
Office of the Director	35	35	31
Research facilities	32	42	49
John E. Fogarty Center	10	10	9
TOTAL	$3712	$3589	$3280

a Estimates. b Actual. Note: Obligations.

Department of Energy's civilian R&D budget up slightly to $4.2 billion

	Authorities		Outlays	
$ Millions	1981	1980	1981	1980
Fossil energy	**$1123.5**	**$858.4**	**$897.7**	**$891.0**
Coal	**957.8**	**669.6**	**726.0**	**701.1**
Liquefaction	523.9	250.5	329.7	214.0
Gasification	148.5	126.0	118.0	180.2
Combustion systems	68.5	57.5	61.0	74.8
Advanced research	59.5	51.4	49.6	60.8
Mining R&D	46.5	68.9	43.4	66.5
Heat engines and heat recovery	43.4	50.5	45.1	63.0
Environmental control	42.5	38.3	49.7	24.1
Fuel cells	25.0	26.5	29.5	17.7
Petroleum and natural gas	**93.7**	**96.2**	**91.9**	**109.2**
Enhanced recovery	50.2	58.8	58.8	74.9
Oil shale	36.1	28.3	24.1	29.2
Advanced technology	7.4	9.1	9.0	5.1
Magnetohydrodynamics	**72.0**	**92.6**	**79.8**	**80.7**
Nuclear	**768.2**	**1073.3**	**880.0**	**1110.9**
Breeder reactor systems	**372.8**	**750.4**	**475.7**	**778.4**
Liquid metal	299.8	614.9	375.7	621.3
Water cooled	61.0	60.0	68.0	69.0
Fuel cycle R&D	12.0	30.0	23.0	33.1
Gas cooled	—	26.0	9.0	26.0
Thermal reactor fuel cycle	—	19.5	—	29.0
Commercial waste management	**298.9**	**220.0**	**295.6**	**216.9**
Converter reactor	**53.5**	**64.5**	**65.0**	**70.3**
Thermal reactor	48.5	57.0	53.0	51.1
Advanced reactor systems	5.0	7.5	7.7	6.2
Gas-cooled thermal reactors	—	—	4.3	13.0
Advanced nuclear systems	**43.0**	**38.4**	**43.7**	**45.3**
Space & terrestrial applications	40.0	36.4	40.7	41.0
Systems evaluation	3.0	2.0	3.0	4.3
General sciences	**521.8**	**470.9**	**506.9**	**460.1**
High-energy physics	358.0	324.5	349.3	315.6
Nuclear physics	115.2	104.4	111.7	105.7
Life sciences research	48.6	42.0	45.9	38.8
Magnetic fusion	**400.5**	**352.5**	**460.8**	**372.3**
Solar	**386.5**	**384.3**	**383.9**	**384.5**
Photovoltaics	140.0	147.0	118.5	131.5
Thermal power system	117.5	121.0	141.4	135.7
Wind energy systems	80.0	63.4	74.7	63.4
Ocean systems	39.0	46.0	39.3	47.0
Solar Energy Research Institute	10.0	6.9	10.0	6.9
Conservation	**269.5**	**283.9**	**256.0**	**237.3**
Transportation	113.0	117.5	111.6	100.0
Buildings and community systems	97.6	106.1	93.1	87.4
Industrial	58.9	60.3	51.3	49.9
Basic energy sciences	**257.3**	**226.8**	**262.0**	**242.4**
Materials sciences	99.9	97.0	106.9	108.2
Chemical sciences	74.4	65.0	75.2	68.0
Nuclear sciences	34.8	32.0	33.8	32.7
Engineering, mathematical	30.7	21.3	29.3	21.8
Biological energy research	9.2	6.3	8.8	6.4
Advanced energy projects	8.3	5.2	8.0	5.3
Environmental R&D	**250.0**	**225.3**	**242.2**	**219.8**
Geothermal	**142.0**	**138.4**	**142.6**	**134.2**
Energy storage	**70.8**	**65.0**	**73.2**	**62.0**
Biomass	**63.0**	**56.0**	**60.1**	**55.5**
TOTAL	**$4253.1**	**$4134.8**	**$4165.4**	**$4170.0**

Note: All numbers are estimates.

search would receive $60 million, down 8%, in 1981. The $27 million (up 21%) allocated to drinking water research in 1981 would zero in on improving the ability of small communities to meet national drinking water standards.

Interdisciplinary research, designed to identify emerging problems before they reach the crisis stage, would receive nearly $23 million in 1981, very slightly more than in 1980. Initiatives in this category would focus on carcinogens, environmental benefits, biological monitoring, and integrated assessments of emerging or latent environmental problems. EPA also plans to contribute funds to interagency research on acid rain.

Even in this "restrained" 1981 budget, basic research efforts at the Department of Commerce will not be slighted, assistant secretary for administration Elsa A. Porter says. Indeed, Commerce's R&D obligations for fiscal 1981 would increase a modest 2% to $379 million, but obligations for basic research would increase almost 29% to $36 million. Of the total R&D funds, the National Bureau of Standards would receive all of the $8 million increase, boosting its budget to $84 million, primarily to expand its basic measurements and standards research. A major NBS effort will be development and commercialization of very-large-scale integrated circuits.

The National Oceanic & Atmospheric Administration would obligate $218 million, the same level as fiscal 1980, for R&D to improve environmental prediction and warning capabilities, among other things. New NOAA initiatives would include development of advanced weather radar equipment to improve severe weather warnings, multispecies (fisheries) management research, and an ocean-heat-storage-field experiment for climate research.

With DOD, NOAA plans to develop a National Oceanic Satellite System. To this end, NOAA's 1981 budget would obligate $6.4 million, about one quarter of the 1981 cost. NOAA also has been designated the lead federal agency for operating civilian satellites, which means that the experimental LANDSAT system has now been transferred from NASA to NOAA. NOAA deputy administrator James (Bud) Walsh says that the agency intends to develop the LANDSAT system to the commercial stage.

Commerce also would receive new responsibility for industrial innovation. Its programs in this area, which draw from a budget request of $10.2 million, are part of a larger federal effort to encourage industrial innovation, Porter says. Commerce has asked for $3 million in fiscal 1981 to enhance the transfer of federal and foreign technology, $5.2 million to set up three nonprofit centers for "generic technology" to be financed jointly with private industry, and $1.9 million "to develop and evaluate operational strategies," Porter adds. ☐

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Protecting Worker Fertility

Concern grows over reproductive hazards Page 28

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News of the Week

- ***Fertilizer producers are doing well*** *this year, partly because forecast ammonia overcapacity didn't materialize, but phosphate makers face export embargo.* ***Page 6***
- ***Exports of phosphates to the U.S.S.R.*** *have been suspended by the Commerce Department via licensing procedure.* ***Page 7***
- ***Uniroyal's Rovel*** *weather-resistant plastics are made of styrene-acrylonitrile resin compounded with olefinic rubber.* ***Page 7***
- ***Scientific research stagnation*** *threatens U.S. universities, NRC study says; urges support of new, young scientists.* ***Page 7***
- ***New Institute of Neurotoxicology*** *will study the effect on the human nervous system of exposure to toxic substances.* ***Page 8***
- ***Striking oil refinery employees*** *have been joined by oil field workers, which may increase pressure on companies.* ***Page 8***

Business

- ***Reinforced plastics demand*** *likely will slip 5% this year, following disappointing 2% rise in 1979, mainly because of drops in boat and auto markets.* ***Page 11***

Government

- ***Regulatory agency budgets are up*** *for fiscal 1981, but inflation will determine real level of growth or decline.* ***Page 14***
- ***Opposition fails to halt final okay*** *on Chesapeake Bay oil refinery; first to be built on East Coast since 1957.* ***Page 15***

Science

- ***U.S. scientists and government*** *move to restrict scientific relations with Soviets in response to invasion of Afghanistan and detention of Sakharov.* ***Page 17***
- ***Peptide sex hormones*** *and their derivatives are being tested as possible male and female contraceptives.* ***Page 18***

Technology

- ***Spent gas lecture bottles****—which many users find hard to dispose of safely—will be bought back by Matheson.* ***Page 27***

News Feature

- ***Reproductive hazards in the workplace*** *is growing issue involving chemical firms, unions, workers' rights groups, and several federal agencies.* ***Page 28***

ACS News

- ***ACS long-term goals*** *and specific goals for 1980 have been approved by ACS Board of Directors and ACS Council.* ***Page 36***
- ***U.S. court has ruled*** *it doesn't have jurisdiction in dispute between ACS and former president Alan Nixon.* ***Page 37***

Books

- ***"Scientists in Power"*** *uses development of nuclear power in France as the basis for a discussion of relationship of scientists to society.* ***Page 49***

Reinforced plastics head for slump in 1980

Overall market expected to be down 5% this year following meager 2% gain in 1979; big problem, as in past slowdown, is in boats and autos

After growing about 75% during the U.S. economic expansion since 1975, the reinforced plastics market has slipped into one of its periodic pauses. Demand rose a disappointing 2% in 1979 from 1978 and is expected to drop 5% in 1980. The net result is that the market has been idling for three years at about 2 billion lb.

The reason for the lull is the same as in past economic slowdowns. Reinforced plastics are very vulnerable to drops in markets for big-ticket consumer durables—especially automobiles and boats.

Reinforced plastics market developers like to say their products can depend on new penetration, especially in poundage used per auto, to spare them from cyclical downswings. That appears to be partially true, since reinforced plastics' use in the land transportation market rose in 1979 despite the drop in U.S. auto sales from 1978. However, penetration was not good enough to bring reinforced plastics up to their target 9% growth in this area in 1979.

The worst showing of reinforced plastics in 1979 and the worst expected in 1980 is in the marine market. In this area even reinforced plastics marketers admit they don't have enough penetration possibilities left to counter a bad economic cycle. In what used to be the biggest reinforced plastics market, use in 1979 sank 10%. In 1980, producers fear another 11% market drop. The big problem is the medium-sized boat market for 14- to 18-footers. Although the larger boat market held up fairly well, this middle area was a disaster in 1979 as boat-buying plans vanished in the face of record high interest rates for loans.

These market figures for boats and other areas came out last week at the annual conference of the Reinforced Plastics Composites Institute of the Society of the Plastics Industry in New Orleans. The institute's annual market survey is the work of Laura Morrison of Morrison-Gottlieb public relations firm, New York City.

The survey measures the total weight of reinforced plastics used in markets for U.S. production. This includes the resin, most notably thermoset polyester; the reinforcement, predominantly glass; and additives, including a fast-rising group of fillers replacing resin. The last development is undoing the old rule of thumb that the highly fragmented reinforced plastics market could be approximated through production of resin or glass. It is also hurting resin producers.

Now fillers are an increasing part of the final product. Fillers include sand, mica, glass spheres, and even fly-ash spheres. Besides saving on cost over increasingly high-priced resin, the fillers have other advantages such as sometimes speeding up production cycles, improving fire resistance, and stepping up impact resistance.

Auto companies are giving hollow glass spheres a tryout in reinforced plastics parts such as one roof panel now in production. More ambitious scaleup would use plastics containing glass spheres for the entire auto body to gain a 20% overall weight saving.

However, such dramatic new uses, like other grand schemes reinforced plastics producers have for cars (such as an all graphite-reinforced plastic auto), are still a long way from reality. For now, reinforced plastics makers are content with laborious part-by-part penetration into Detroit's specifications for autos and trucks.

A good example of a breakthrough of this nature is an all-plastic three-piece door on Astro and General trucks this year. The producer of the molded part, Premix Inc. of Lancaster, Ohio, calls this "the first vehicle body component subject to mechanical stress to be successfully mass produced of reinforced plastics using no metal supports or stiffeners." The two truck doors give a weight saving of 80 lb over conventional metal doors.

Such new uses keep transportation the brightest hope for reinforced plastics in the 1980's despite a weak start. Of help in this market is growing use of reinforced thermoplastics, which find their biggest outlet in autos. The thermoplastic contingent grew 14% in 1979 from 1978 to 246 million lb, 12% of total reinforced plastics. For 1980, the outlook is a 3% drop to 238 million lb. □

Reinforced plastics demand expected down in 1980 for six of nine major markets

								% change		
Millions of lb	1980[a]	1979[a]	1978	1977	1976	1975	1970	1979-80	1978-79	1970-80
Transportation, land	522	550	535	475	398	265	131	−5%	3%	15%
Marine	342	385	430	400	365	285	183	−11	−10	6
Construction	320	335	320	286	248	175	115	−4	5	11
Anticorrosion	226	238	216	192	157	163	73	−5	10	12
Electrical	182	180	170	147	123	82	59	1	6	12
Appliance	130	130	123	112	98	64	29	0	6	16
Consumer goods	114	126	116	107	102	64	67	−10	9	5
Aircraft	24	23	22	21	22	24	27	4	5	−1
Other	77	79	74	70	66	53	89	−3	7	−1
TOTAL	**1937**	**2046**	**2006**	**1810**	**1579**	**1175**	**773**	**−5%**	**2%**	**10%**

[a] Estimates. **Source:** Reinforced Plastics/Composites Institute of the Society of the Plastics Industry

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U.S. chemical earnings up, but softness shows Page 8

West German chemical companies' unique research commitment Page 15

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News of the Week

- ***Administration's nuclear waste management*** *program focuses on disposal sites, sets up state planning council.* ***Page 4***
- ***District court judge*** *orders EPA to begin testing 18 potentially hazardous chemicals as required under TSCA.* ***Page 5***
- ***Yale University will rent lab space*** *to Miles Laboratories for research on preclinical pharmacology.* ***Page 5***
- ***Salary differences*** *of women and minority-group scientists vs. white males in the federal work force are decreasing.* ***Page 5***
- ***Chemical companies are big contributors*** *to total corporate philanthropy, which reached the $2 billion mark in 1978.* ***Page 6***
- ***Synfuels program*** *could cause a shortage of engineering personnel, supplies.* ***Page 6***

Business

- ***Top 40 U.S. chemical firms*** *averaged 21% earnings gain in fourth-quarter 1979—below year ago but over predictions.* ***Page 8***

International

- ***West German chemical makers strong on R&D,*** *cultivate interaction among industry and universities.* ***Page 15***

Government

- ***OSHA chief Eula Bingham,*** *undaunted by stormy tenure, cites successes, is optimistic about agency's future.* ***Page 23***
- ***Controversy over sweetener aspartame*** *remains unresolved as FDA's first public board of inquiry ends.* ***Page 25***
- ***Data bank*** *available for* Federal Register *is new aid for those who track chemicals through government maze.* ***Page 26***

Science

- ***Synthesis of leukotriene C*** *will facilitate laboratory study of the biologically potent, asthma-related molecule.* ***Page 28***
- ***Enthusiasm of participants*** *in industry/academe conference held last year prompts scheduling of followup meeting.* ***Page 30***

Technology

- ***Fermilab's Tevatron accelerator*** *will double current energy peak, set the pace for large-scale superconductivity systems.* ***Page 31***

News Feature

- ***Federal guidelines*** *proposed to protect against reproductive hazards in workplace raise conflicting responses.* ***Page 35***

Books

- ***"The Politics of Peril"*** *warns western scientists—join concern for persons and society to reason or face nuclear war.* ***Page 39***

Final Program

- ***Complete technical and general programs*** *for the Houston ACS meeting.* ***Page 42***

Earnings gain off, but better than expected

Increase in chemical earnings slipped to 21% in fourth quarter after four quarters of larger gains; full-year earnings spurted 29%

William J. Storck
and William F. Fallwell
C&EN, New York

The fourth quarter of 1979 turned out much better for chemical companies than many in the industry thought it would. Earlier predictions by analysts had put earnings gains from fourth-quarter 1978 at anywhere from flat to 10%.

In fact, the increase for 35 of the top 40 U.S. chemical companies averaged 21% for earnings and 23% for sales.

The earnings gain for the chemical companies proves the cliché, "It depends upon your point of view." As recently as a year and a half ago, a 21% gain in earnings performance would have been viewed as very good news. Then in the fourth quarter of 1978, chemical earnings took off. They increased an average of 36% in the fourth quarter of 1978, and in the first three quarters of 1979 they increased 36%, 34%, and 30%. So now, the 21% gain in the fourth quarter must be viewed as bad news, representing a considerable slowing in the chemical economy.

For the full year, the news was good. As C&EN predicted earlier (C&EN, Nov. 12, 1979, page 10), sales for the industry for all of 1979 increased 22%. Earnings rose 29%, one percentage point higher than C&EN forecast. The greater increase in earnings over sales raised chemical profit margins from an average of 6.0% in 1978 to 6.6% in 1979. This is the highest full-year profit margin since 1976, when it was 6.7%.

However, as it was in the third quarter, the average profit margin is being held up by the smaller, less diversified companies, such as Freeport Minerals, Texasgulf, Nalco Chemical, and Big Three Industries.

In general, fourth-quarter earnings held up fairly well. But they were affected considerably by some big nonrecurring items at some of the larger companies. For instance, Dow Chemical had a nonrecurring gain of 28 cents a share. The elimination of this gain lowered the company's earnings increase for the fourth quarter from 41% to 4%.

However, there was a definite weakness in some parts of the chemical companies' markets in the fourth quarter. Most notable among the weak markets was fibers, dragging down earnings and profit margins at some companies. At Du Pont, fibers sales were almost $1.1 billion, a 21% increase in the fourth quarter over the same period in 1978. But income from fibers fell 16.5% to $69.2 million. At Allied Chemical, operating profits from its fibers and plastics division fell 16% from a year ago. Fibers earnings at Celanese dropped 57% from a year ago, and the company lost 12 cents a share on U.S. polyester and nylon. In fact, cellulosics were the only fibers to show an increase at Celanese; they were up 45%. And at Akzona, net after-tax operating income at its American Enka operation decreased 18% to $5.3 million in the fourth quarter.

However, probably the worst case was at Monsanto, where the company had a net loss in its fibers operations of $44.7 million, compared to a loss of $19.8 million in fourth-quarter 1978. In all of 1979, Monsanto lost more than $168 million in its textile operations. In 1978, these same operations lost $29.2 million.

And that was not all of the bad news at Monsanto. The firm's plastics and resins operations also showed a big loss in the fourth quarter—in this case $28.2 million. In fourth-quarter 1978 the same business had a modest loss of $500,000.

As they have been all year, chemical companies were complaining about raw material costs in 1979's last three months. Du Pont attributes its 6% decline in earnings primarily to

Chemical industry leaders for fourth-quarter 1979 . . .

Rank	Sales	$ Millions	Earnings	$ Millions[a]	Profitability	Earnings as % of sales
1	Du Pont	$3176.5	Du Pont	$206.1	Freeport Minerals	20.0%
2	Dow Chemical	2447.3	Dow Chemical	143.6	Texasgulf	20.0
3	Union Carbide	2396.0	Union Carbide	131.9	International Flavors	13.5
4	Monsanto	1547.9	Allied Chemical	67.4	Big Three Industries	12.6
5	W. R. Grace	1471.9	W. R. Grace	63.9	Nalco Chemical	11.1
6	Allied Chemical	1298.3	Diamond Shamrock	58.5	Stauffer Chemical	9.7
7	American Cyanamid	857.0	American Cyanamid	45.5	First Mississippi	9.0
8	Celanese	814.0	Texasgulf	44.2	Petrolite	9.0
9	Diamond Shamrock	666.1	International Minerals	37.8	Diamond Shamrock	8.8
10	Hercules	596.0	Stauffer Chemical	35.9	Air Products	8.6

. . . and for full-year 1979

Rank	Sales	$ Millions	Earnings	$ Millions[a]	Profitability	Earnings as % of sales
1	Du Pont	$12,571.8	Du Pont	$938.9	Freeport Minerals	20.8%
2	Dow Chemical	9,255.4	Dow Chemical	733.2	Texasgulf	17.3
3	Union Carbide	9,176.2	Union Carbide	556.4	International Flavors	15.0
4	Monsanto	6,195.2	Monsanto	338.4	Big Three Industries	12.3
5	W. R. Grace	5,266.6	W. R. Grace	222.6	Nalco Chemical	11.1
6	Allied Chemical	4,332.4	Diamond Shamrock	178.1	Stauffer Chemical	8.9
7	American Cyanamid	3,187.0	Allied Chemical	175.6	International Minerals	8.5
8	Celanese	3,146.0	American Cyanamid	168.5	Petrolite	8.3
9	Diamond Shamrock	2,351.6	Hercules	144.5	Air Products	8.1
10	Hercules	2,350.0	Celanese	143.0	Dow Chemical	7.9

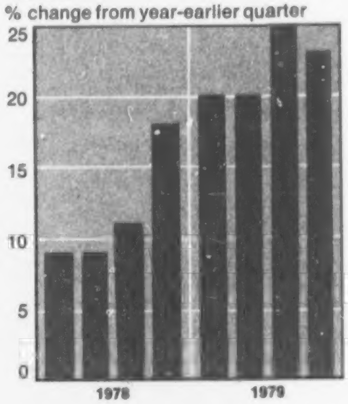
[a] After taxes. **Note:** For basic chemical companies with half or more of their sales in chemicals.

Chemical Industry 1979 Final Results

- **Sales continued big gains**
- **Earnings increase slowed**
- **Profit margins fell again**
- **Production increased 4.1%**
- **Prices shot up 16.6%**

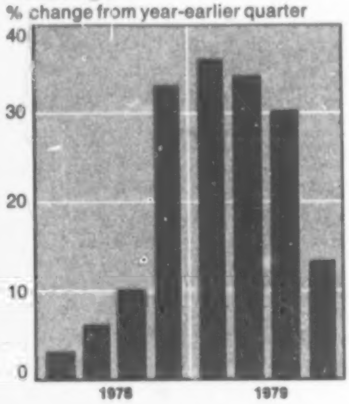
Sales

% change from year-earlier quarter



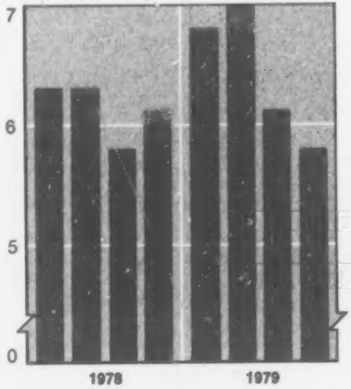
Earnings

% change from year-earlier quarter



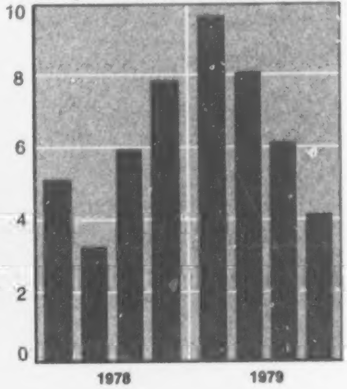
Profit margins

After-tax earnings as % of sales



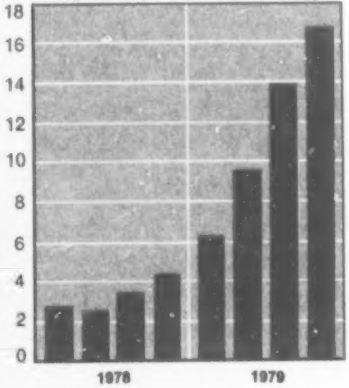
Production

% change from year-earlier quarter



Prices

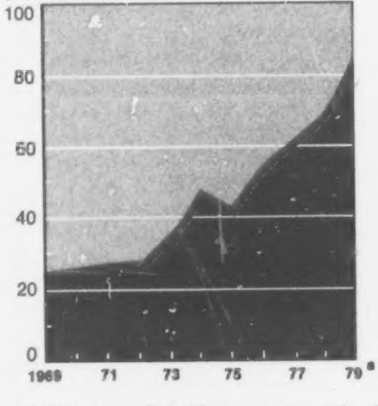
% change from year-earlier quarter



For the full year, sales increased 22% to top $83 billion, while earnings increased 28% to almost $5.3 billion; profit margins increased to 6.4%

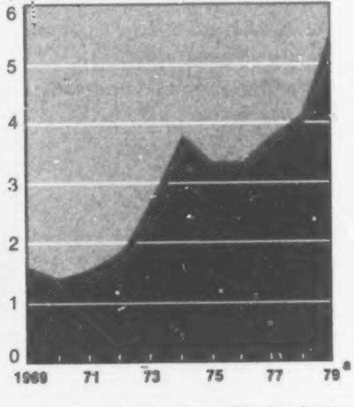
Annual sales

$ Billions



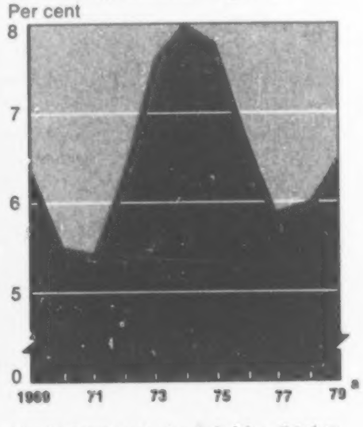
Annual earnings

$ Billions



Annual profit margins

Per cent



[a] C&EN estimates. **Note:** All sales, earnings, and profit margin data are based on the combined performance of the 40 largest basic chemical makers listed on page 10.

Fourth-quarter earnings increased 21% for chemical firms; profit margins off slightly

	FOURTH-QUARTER 1979						FULL-YEAR 1979			
	Sales	Earnings	Change from 1978		Profit margin[a]		Sales	Earnings	Change from 1978	
	($ millions)		Sales	Earnings	1979	1978	($ millions)		Sales	Earnings
Du Pont	$3,176.5	$206.1	11%	−6%	6.5%	8.2%	$12,571.8	$938.9	19%	19%
Dow Chemical	2,447.3	143.6	35	4	5.9	7.6	9,255.4	733.2	34	27
Union Carbide	2,396.0	131.9	15	28	5.5	4.9	9,176.2	556.4	17	51
Monsanto	1,547.9	18.2	19	−59	1.2	3.4	6,195.2	338.4	23	12
W. R. Grace	1,471.9	63.9	20	66	4.3	3.1	5,266.6	222.6	18	30
Allied Chemical	1,298.3	67.4	67	72	5.2	5.0	4,332.4	175.6	44	15
American Cyanamid[d]	857.0	45.5	16	4	5.3	5.9	3,187.0	168.5	15	8
Celanese	814.0	29.0	18	−17	3.6	5.1	3,146.0	143.0	21	28
Diamond Shamrock[d]	666.1	58.5	40	27	8.8	9.7	2,351.6	178.1	29	28
Hercules	596.0	26.8	18	8	4.5	4.9	2,350.0	144.5	21	40
National Distillers	558.7	32.6	6	6	5.8	5.8	2,114.9	117.3	14	[illegible]
Williams Cos.	460.1	23.4	35	e	5.1	e	1,850.0	69.5	24	151
International Minerals	443.5	37.8	28	35	8.5	8.0	1,642.5	140.0	17	24
Olin	441.0	15.5	8	5	3.5	3.6	1,800.0	71.1	13	13
Ethyl	431.1	22.0	14	8	5.1	5.4	1,657.0	97.5	16	13
Rohm & Haas	387.8	18.2	26	39	4.7	4.2	1,590.5	95.5	27	65
Stauffer Chemical	369.7	35.9	14	6	9.7	10.4	1,526.2	136.0	15	8
Cabot[f]	354.2	27.5	50	71	7.8	6.8	1,241.0	81.9	54	53
Air Products	317.4	27.3	15	12	8.6	8.9	1,271.7	102.9	18	24
Pennwalt	283.3	11.9	22	13	4.2	4.5	1,079.3	48.0	17	7
Akzona	275.6	6.9	23	25	2.5	2.4	1,012.4	25.6	17	23
Witco Chemical	261.1	9.5	24	−1	3.6	4.6	966.8	42.8	29	28
Reichhold Chemicals	222.4	2.5	18	−11	1.1	1.5	874.9	13.4	16	−8
Texasgulf	220.3	44.2	29	195	20.0	8.8	789.3	136.9	31	173
Lubrizol[g]	—	—	—	—	—	11.7	—	—	—	—
Thiokol[g]	—	—	—	—	—	4.2	—	—	—	—
Nalco Chemical	158.5	17.7	20	17	11.1	11.4	578.9	64.5	22	20
Ferro	157.1	8.7	18	—	5.5	6.6	592.9	30.9	20	12
Big Three Industries	136.0	17.1	16	10	12.6	13.2	509.6	62.8	19	11
Freeport Minerals	130.3	26.0	59	177	20.0	11.5	487.7	101.4	60	224
Liquid Air	98.7	6.3	32	117	6.4	3.9	369.1	24.7	21	35
International Flavors	92.1	12.4	7	2	13.5	14.1	409.3	61.5	12	9
Mallinckrodt[g]	—	—	—	—	—	8.8	—	—	—	—
First Mississippi	61.4	5.5	44	e	9.0	e	237.4	14.8	51	2,860
Crompton & Knowles	60.8	2.5	5	14	4.1	3.8	239.6	7.1	10	16
Beker Industries[g]	—	—	—	—	—	e	—	—	—	—
Petrolite	51.1	4.6	15	5	9.0	9.9	186.9	15.6	12	2
Royster	48.0	2.2	56	e	4.6	e	268.4	7.6	43	347
Stepan Chemical[g]	—	—	—	—	—	3.4	—	—	—	—
Virginia Chemicals	32.5	−0.1	19	e	e	3.1	131.3	4.2	19	6
Total 20 largest companies[h]	**$19,317.0**	**$1073.0**	**23.0%**	**16.1%**	**5.6%**	**5.9%**	**$73,605.3**	**$4558.9**	**22.4%**	**25.7%**
Total 15 other companies[h]	**$2,005.9**	**$166.0**	**23.6%**	**61.0%**	**8.3%**	**6.4%**	**$7,648.5**	**$613.8**	**21.6%**	**58.9%**
GRAND TOTAL[h]	**$21,322.9**	**$1239.0**	**23.2%**	**20.6%**	**5.8%**	**5.9%**	**$81,253.8**	**$5172.7**	**22.3%**	**28.9%**

[a] After-tax income as percentage of net sales. [b] Fully diluted before nonrecurring items and extraordinary charges for continuing operations. [c] As of Jan. 31. [d] Includes nonrecurring items. [e] Deficit. [f] 1979 results include acquisitions not included in 1978. [g] Not all data available at press time. [h] Averages except for sales and earnings.

what it calls sharp increases in prices of raw materials and energy. Du Pont says that prices paid for hydrocarbons, which include petrochemical feedstocks, increased 63% in the fourth quarter over the same period of 1978. And silver prices doubled, which had a great impact on the company's photographic products, which use large amounts of silver for x-ray, graphic arts, and industrial films. In all, Du Pont's index for all of its purchased materials increased 38% from the fourth quarter of 1978. At the same time its selling price index for the total company rose only 11%.

At Hercules, Alexander F. Giacco, president and chief executive officer, says that for the year as a whole, raw material costs were up 15.7% and energy costs were up 20.9%. He adds, "Should this trend continue into 1980, our success will depend on our ability to increase our prices to recover the higher costs, and our plans have been made accordingly."

At Rohm & Haas, feedstock costs in the fourth quarter increased 27% over the year before, but selling prices were up only 12%. And at Reichhold Chemical, president Peter J. Fass says that "operating margins were narrowed, primarily from continued rapid escalation in petrochemically derived raw materials, which increased in price more rapidly than product sales prices. Operating costs with high energy content continued their sharp increases, reflecting international crude oil and hydrocarbon price escalations."

FULL-YEAR 1979		Earnings per share[b]		STOCK MARKET DATA					
Profit margin[a]			Recent	Stock price[c]	Recent 12 months		Price-earnings ratio Jan. 31	Annual indicated dividend	Dividend yield, % of price
1979	1978	4th qtr	12 months	Jan. 31	High	Low			
7.5%	7.4%	$1.41	$6.42	$40¾	$45⅞	$ 7	6.3%	$2.75	6.7%
7.9	8.4	0.80	4.05	34⅛	35⅝	24⅜	8.4	1.60	4.7
6.1	4.7	1.99	8.47	43¾	47⅞	35	5.2	3.00	6.9
5.5	6.0	0.50	9.23	56¼	62¾	45	6.1	3.40	6.0
4.2	3.8	1.37	4.79	41¾	43⅛	25⅝	8.7	2.05	4.9
4.1	5.1	2.20	5.95	56½	57¾	28½	9.5	2.00	3.5
5.3	5.6	0.95	3.52	32	36⅛	24⅜	9.1	1.60	5.0
4.5	4.3	1.94	9.46	48½	50	39¾	5.1	3.20	6.6
7.6	7.7	1.10	3.37	33⅜	35½	19⅛	9.9	1.60	4.8
6.1	5.3	0.60	3.27	22½	24⅝	16⅞	6.9	1.10	4.9
5.5	5.7	0.96	3.41	30¼	32½	19⅜	8.9	2.00	6.6
3.8	1.9	0.86	2.55	36½	38⅜	17	14.3	1.10	3.0
8.5	8.1	2.08	7.15	54	61½	38¾	7.6	3.00	5.6
4.0	3.9	0.64	2.97	17¼	25	16⅛	5.8	1.00	5.8
5.9	5.8	1.07	4.77	29⅝	30½	22¼	6.2	1.50	5.1
6.0	4.4	1.40	7.39	42¼	48½	33	5.7	2.00	4.7
8.9	9.5	0.81	3.10	18⅞	25	17¾	6.1	1.10	5.8
6.4	6.6	2.65	7.91	61⅛	62	34	7.7	1.60	2.6
8.4	7.5	0.96	3.63	38½	42⅛	25	10.6	0.80	2.1
4.4	4.5	1.20	4.81	33¾	35⅞	30¼	7.0	2.20	6.5
2.5	2.4	0.57	2.10	14⅛	17⅛	11⅜	6.7	0.80	5.7
4.4	4.5	—	—	29¼	33	20½	—	1.40	4.8
1.5	1.9	0.26	1.43	13⅛	16½	11⅛	9.2	0.74	5.6
17.3	8.3	1.18	3.71	47⅛	50¼	21⅛	12.7	1.20	2.5
—	13.0	—	—	62⅞	64½	41	14.4	1.80	2.9
—	4.6	—	—	56	58	30½	9.8	1.55	2.8
11.1	11.3	0.83	3.18	32½	35⅝	27¾	10.2	1.60	4.9
5.2	5.6	1.14	4.07	22⅝	27¾	19	5.6	1.20	5.3
12.3	13.2	0.85	3.13	46⅝	47¾	31⅝	10.1	0.88	1.9
20.8	10.3	1.24	4.84	62¾	66½	30	13.0	1.50	2.4
6.7	6.0	0.58	2.49	24¾	28¾	23½	9.9	1.40	5.7
15.0	15.4	0.34	1.68	19¾	24⅜	18¼	11.8	0.80	4.1
—	7.9	—	—	29½	33¼	26¾	9.0	1.20	4.1
6.2	0.3	0.64	1.73	31⅝	33	12	18.3	0.40	1.3
3.0	2.8	1.08	3.05	18⅞	18⅞	14	6.2	1.20	6.4
—	e	—	—	13⅜	16	4⅜	—	—	—
8.3	9.2	0.78	2.64	45½	52½	35¼	17.2	1.08	2.4
2.8	0.9	0.31	0.43	15⅜	16¼	4⅝	35.8	0.40	2.6
—	3.8	—	—	21½	23½	16½	7.8	0.92	4.3
3.2	3.6	−0.2	1.62	14½	12¾	15½	9.0	0.70	4.8
6.2%	**6.0%**								
8.0%	**6.1%**								
6.4%	**6.0%**								

And Dow Chemical happily reflects that although increased sales were fueled largely by price increases made necessary by huge jumps in energy and hydrocarbon costs, gains were made in real terms. G. J. Williams, financial vice president at Dow, says that in terms of physical volume, sales rose 10%. This increased volume, he says, was reflected in Dow's operating rate, which rose from 79% of capacity in 1978 to 84% for full-year 1979.

A weakness in certain parts of the economy—notably housing construction and automobiles—is having a negative effect on chemical earnings. H. Barclay Morley, chairman and president of Stauffer Chemical, says that fourth-quarter volume in those areas reflects general economic conditions such as the automotive and housing markets, but that many of Stauffer's specialized products are continuing to show strength into 1980. John W. Hanley, chairman and president of Monsanto, says, "During the fourth quarter, inventory corrections by customers resulted in a significant drop in shipments and a modest buildup in inventory in our own plants. Products for the automotive and residential construction industries in the U.S. were particularly hard hit." And American Cyanamid says that the downturn in construction adversely affected its earnings.

One of the bright spots for earnings in the fourth quarter remained agricultural chemicals. Cyanamid's chairman and chief executive officer James G. Affleck says that the com-

Profit margins still rise for oil firms but drop for other diversified companies

		4TH-QUARTER 1979						FULL-YEAR 1979		
	% Chemical sales	Sales ($ millions)	Earnings ($ millions)	Change from 1978 Sales	Change from 1978 Earnings	Profit margin[a] 1979	Profit margin[a] 1978	Sales ($ millions)	Earnings ($ millions)	Change from 1978 Sales
OIL AND GAS COMPANIES										
Exxon[b]	8%	$25,295.0	$1,365.0	39%	60%	5.4%	4.7%	$84,350.0	$4,295.0	30%
Mobil[b]	3	14,490.0	541.0	36	72	3.7	2.9	47,946.0	2,010.0	28
Texaco	2	12,013.0	533.9	45	63	4.4	4.0	39,096.0	1,759.1	34
Standard Oil of California	4	9,800.0	524.0	44	66	5.3	4.6	31,800.0	1,735.0	29
Gulf Oil	9	7,727.0	366.0	42	54	4.7	4.4	26,137.0	1,322.0	30
Standard Oil (Ind.)	12	6,069.9	368.7	41	70	6.1	5.0	20,215.3	1,506.6	24
Atlantic Richfield	9	5,049.6	383.0	54	72	7.6	6.8	16,676.7	1,205.9	31
Shell Oil	18	4,301.3	331.2	47	72	7.7	6.6	14,546.2	1,125.6	31
Conoco	6	3,800.0	190.7	34	23	5.0	5.5	13,100.0	815.4	33
Tenneco	9	3,269.0	164.0	33	25	5.0	5.3	11,209.0	571.0	28
Sun Co.	3	3,200.0	222.9	52	107	7.0	5.1	10,800.0	699.9	42
Phillips Petroleum	16	3,044.8	306.5	38	180	10.1	5.0	9,744.8	891.1	31
Standard Oil (Ohio)	6	2,349.7	451.0	53	174	19.2	10.7	7,916.0	1,186.1	52
Union Oil[c]	11	2,213.4	152.3	32	23	6.9	7.4	7,700.0	500.6	26
Ashland Oil[c]	15	1,928.3	59.4	36	15	3.1	3.6	7,155.8	195.1	29
Cities Service	9	1,804.2	106.2	47	96	5.9	4.4	6,276.7	347.5	35
El Paso	10	906.0	27.6	56	−25	3.0	6.3	3,088.6	138.1	52
Northern Natural Gas	13	775.7	62.1	44	44	8.0	8.0	2,499.2	191.8	30
Kerr-McGee	18	755.5	40.4	39	1	5.3	7.4	2,683.5	160.0	29
American Petrofina	14	492.9	17.7	50	−13	3.6	6.2	1,622.6	83.2	38
DIVERSIFIED MANUFACTURERS										
General Electric	2	6,130.0	382.0	14	5	6.2	6.7	22,460.0	1,410.0	14
U.S. Steel[b]	7	3,000.0	−561.7	0	d	d	3.2	12,900.0	−293.0	17
Procter & Gamble	3	2,622.3	146.7	17	15	5.6	5.7	10,080.6	615.7	15
Eastman Kodak	20	2,587.1	294.7	12	−11	11.4	14.3	8,028.2	1,000.8	14
Esmark[b]	8	1,827.6	26.1	11	12	1.4	1.4	6,771.9	92.4	15
Firestone Tire & Rubber	9	1,419.0	25.1	4	24	1.8	1.5	5,284.4	102.9	8
Georgia-Pacific	8	1,371.0	70.0	16	−7	5.1	6.4	5,207.0	327.0	18
3M	15	1,367.0	167.2	15	14	12.2	12.4	5,440.0	655.2	17
Aluminum Co. of America	5	1,240.0	124.4	9	24	10.0	8.8	4,800.0	493.9	17
Borden	33	1,146.1	29.3	15	−11	2.6	3.3	4,312.5	134.0	13
FMC	35	884.6	40.0	7	7	4.5	4.5	3,307.5	151.6	8
PPG Industries	32	800.7	45.1	9	−9	5.6	6.7	3,100.0	208.9	11
B. F. Goodrich	36	775.3	14.8	14	−27	1.9	3.0	2,988.2	82.6	15
Pfizer	15	743.8	58.6	14	4	7.9	8.6	2,746.0	237.9	14
Borg-Warner	20	716.1	42.0	16	10	5.9	6.2	2,717.4	155.6	17
Kaiser Aluminum	14	713.7	63.8	12	87	8.9	5.4	2,926.5	232.2	20
Northwest Industries	11	691.4	48.5	16	18	7.0	6.9	2,579.9	172.2	9
Merck	16	629.6	81.7	19	14	13.0	13.6	2,384.6	381.8	20
General Tire & Rubber	10	619.2	15.6	−2	−48	2.5	4.8	2,294.9	81.7	4
Martin Marietta	12	569.4	37.3	12	2	5.6	7.2	2,060.8	178.0	17
Eli Lilly	21	541.4	70.5	14	9	13.0	13.6	2,205.8	329.5	19
Koppers	31	508.9	22.0	14	22	4.7	4.3	1,828.3	86.5	16
NL Industries	30	476.4	36.5	16	37	7.7	6.5	1,810.2	114.6	18
SCM	13	472.6	11.8	10	30	2.5	2.1	1,903.8	50.3	17
GAF	23	324.9	7.6	18	−14	2.3	3.2	1,213.2	28.2	14

a After-tax income as percentage of sales. b Earnings include nonrecurring items. c Sales exclude excise taxes. d Deficit. **Note:** Earnings are given before major nonrecurring and extraordinary items. Earnings at companies with major operational reshuffles are given for continuing operations. Earnings per share are fully diluted.

FULL-YEAR 1979			STOCK MARKET DATA							
Change from 1978	Profit margin[a]		Earnings per share		Stock price			Price-earnings ratio Jan. 31	Annual indicated dividend	Dividend yield, % of price
						Recent 12 Months				
Earnings	1979	1978	4th qtr	Recent 12 months	Jan. 31	High	Low			
55%	5.1%	4.3%	$3.10	$ 9.74	$ 60⅞	$ 61¼	$48⅞	6	$4.40	7.2%
78	4.2	3.0	2.55	9.48	58⅜	60⅜	36¼	6	3.00	5.1
106	4.5	2.9	1.97	6.48	34⅞	37⅛	23⅝	5	2.40	6.9
64	5.6	4.4	3.06	10.44	62¼	62⅝	44⅜	6	3.20	5.1
68	5.1	3.9	1.88	6.78	39¼	40¼	23	6	2.25	5.7
40	7.5	6.6	2.45	10.23	87⅝	89¾	53½	9	3.60	4.1
50	7.2	6.3	3.11	9.81	95	97¼	57⅜	10	3.40	3.6
40	7.7	7.3	2.15	7.32	64½	69¼	30¼	9	2.40	3.7
81	6.2	4.6	1.77	7.58	53⅛	55⅞	28¾	7	1.90	3.6
26	5.1	5.2	1.49	5.16	42¾	43¾	29¼	8	2.40	5.6
69	6.5	5.5	3.55	11.15	81	81	42	7	3.00	3.7
63	9.1	7.4	1.98	5.77	54¼	55⅞	30½	9	1.80	3.3
163	15.0	8.7	3.71	9.83	100	102¾	44½	10	2.00	2.0
31	6.5	6.3	1.76	5.76	53¾	54¾	33	9	1.30	2.4
13	2.7	3.1	1.89	5.69	41⅝	45½	32¾	7	2.20	5.3
72	5.5	4.3	3.83	12.54	99	99	53⅛	8	3.60	3.6
27	4.5	5.3	0.59	2.99	27⅜	28⅝	16⅛	9	1.48	5.4
35	7.7	7.4	2.75	8.45	55¼	58⅝	35½	7	3.00	5.4
35	6.0	5.7	1.56	6.18	74⅞	76⅞	46	12	1.55	2.1
157	5.1	2.8	1.65	7.77	40¾	44¾	24½	5	2.50	6.1
15	6.3	6.3	1.69	6.20	55	56¼	45	9	2.80	5.1
d	d	2.2	−6.50	−3.41	19¾	26⅛	16¾	d	1.60	8.1
13	6.1	6.2	1.77	7.45	72⅛	86⅞	70¼	10	3.40	4.7
11	12.5	12.9	1.82	6.20	48¼	66⅞	44	8	2.40	5.0
15	1.4	1.4	1.24	4.40	28⅜	32	23¾	6	1.84	6.5
43	2.0	1.5	0.43	1.78	8⅝	13⅞	8⅛	5	0.60	7.0
8	6.3	6.9	0.65	3.03	28¾	31⅜	23½	9	1.20	4.2
16	12.0	12.1	1.43	5.59	49½	64	46⅝	9	2.40	4.8
58	10.3	7.6	3.51	13.99	63½	64½	48⅜	5	3.20	5.0
−1	3.1	3.6	0.91	4.12	23⅜	27⅞	23¼	6	1.82	7.8
14	4.6	4.8	1.11	4.18	29½	31⅛	22¾	7	1.40	4.7
15	6.7	6.5	1.38	6.47	33¼	34¼	25⅞	5	2.00	6.0
18	2.8	2.7	0.87	4.89	20¼	24	17⅜	4	1.44	7.1
13	8.7	8.7	0.80	3.26	37½	41¾	29	12	1.32	3.5
16	5.7	5.8	1.95	7.25	35⅝	37⅞	26¾	5	2.30	6.5
60	7.9	5.9	1.45	5.28	23	23⅞	17½	4	1.20	5.2
14	6.7	6.4	1.58	5.60	35½	37⅞	25⅛	6	2.05	5.8
24	16.0	15.5	1.08	5.06	68½	75⅝	62½	14	2.30	3.4
−29	3.6	5.3	0.66	3.44	17⅜	26⅞	18	5	1.50	8.6
31	8.6	7.7	1.50	7.10	54	56⅜	30⅛	8	2.12	3.9
19	14.9	15.0	0.97	4.52	57	63⅞	47⅛	13	2.10	3.7
28	4.3	4.0	0.83	3.27	27⅜	28¾	17⅜	8	1.40	5.1
31	6.3	5.7	1.08	3.36	38⅝	39⅜	20¼	11	1.20	3.1
26	2.6	2.4	1.15	4.80	22¾	32	16⅝	5	1.30	5.7
−7	2.3	2.9	0.44	1.62	10⅝	13	9¼	7	0.68	6.4

Oil companies' chemical earnings generally improved in 1979

Outside the basic U.S. chemical industry, the industry with the biggest stake in chemicals is petroleum. Centered in building-block petrochemicals, the chemical operations of oil and natural gas companies tend to be more cyclical than operations in the basic chemical industry. Over the past decade, petrochemicals were slow to feel the financial benefits of a business expansion, jumped suddenly in the last year or two of the expansion, and sank sharply at the beginning of the next expansion. Profits have tended to be a little or a lot.

In 1979, chemical profits were a lot for many oil and natural gas companies, especially the ones most dependent on petrochemicals. With high use of plant capacity, petrochemical producers were able both to pass along sharply increased raw materials and energy costs and to strengthen previously slim profit margins. As with basic chemical companies, U.S. exports and non-U.S. operations gave a major profits boost.

For example, Exxon, by far the biggest chemical power among oil companies, reports that its chemical earnings climbed 68% in 1979 from 1978 to reach $450 million. U.S. chemical earnings increased 30%, and non-U.S. chemical earnings more than doubled.

Exxon chairman C. C. Garvin Jr. comments on the foreign earnings: "Feedstock shortage and strong demand caused a recovery of depressed industry (profit) margins, particularly in Europe. Worldwide return on capital employed was 17.8% in 1979, slightly higher than for the corporation as a whole."

Chemical earnings for another major petrochemical producer, Gulf Oil, more than tripled in 1979 to $275 million. The leading influences behind the jump were increased demand for aromatics such as styrene and cumene as gasoline octane improvers and increased prices for plastics such as low-density polyethylene and polystyrene.

Amid the petrochemical prosperity, however, some oil companies received bad blows in chemicals last year. For example, Atlantic Richfield, which otherwise would have increased chemical earnings, went into the red in the fourth quarter as the company set up a $40 million reserve to cover the loss on its joint-venture ethylene glycol plant outside Houston. And Cities Service's chemical earnings slid into a loss for the whole year, in part because of a battered carbon black market.

$ Millions, operational earnings	Fourth quarter 1979	Fourth quarter 1978	Fourth quarter % Change	Full year 1979	Full year 1978	Full year % Change
Atlantic Richfield	$−29[a]	$29	b	$117[a]	$91	29%
Cities Service	−3	1	b	−1	16	b
Exxon	130	79	65	450	268	68
Gulf Oil	79	29	172	275	81	240
Mobil	18	31	−41	113[a]	86	31
Standard Oil (Ind.)	55	−4	b	202	46	344
Texaco	30	17	72	97	55	77

a Earnings lowered significantly by nonrecurring item. b Deficit in either 1979 or 1978.

pany's "agricultural segment performed exceptionally well" with animal feed and health products and fertilizers leading the way.

At Freeport Minerals, earnings from agricultural minerals in the fourth quarter increased 155% over fourth-quarter 1978 and more than 145% for the year.

And it seems that the fertilizer producers see the good times continuing despite uncertainty caused by the question of trade with the Soviet Union (C&EN, Feb. 11, page 6). At Royster, which manufactures phosphate fertilizers, J. W. Parnell Jr., president and chief executive officer, says of the U.S. embargo of grain shipments that speculation about further measures and possible changes in Department of Agriculture programs has created some uncertainty regarding farmers' planting intentions and government set-aside programs. "Thus far, however, we do not see an impact materially affecting Royster," Parnell says. And he expects strong domestic demand for fertilizers to last into spring.

And at International Minerals, chairman R. A. Lenon says that the U.S. embargo on shipments of grain to the Soviets will have no short-term impact on the company's fertilizer business, and, as seen now, very little impact longer term. "The outlook for fertilizers has been progressively improving," Lenon says.

Fertilizer also was a good investment in 1979 for the many diversified producers outside the basic chemical industry with a stake in this market. The same optimism carries into 1980, unlike prospects for a number of other chemical businesses.

For example, Borden's chairman, Eugene J. Sullivan, says that the company's fertilizer operation had an excellent year in 1979. This performance and an outstanding year for the company's petrochemical-based products, notably polyvinyl chloride, more than offset lower profits from construction-oriented thermoset resins.

The Estech unit of Esmark also notes strength in 1979 in fertilizer and says that the outlook for world fertilizer prices continues to be optimistic. Estech's overall chemical results in 1979 also showed higher operational profits before nonrecurring items.

Some agricultural specialties turned in large gains in 1979. At Eli Lilly, the hugely successful herbicide, Treflan, powered agricultural chemical sales to a 40% gain to $470.8 million in 1979. Lilly doesn't disclose profits for this product line.

In nonagricultural chemical markets, a number of diversified companies report improved results in 1979 although other of their major product lines deteriorated financially. For example, while construction-related lines such as wood and glass began to feel weakness in 1979, chemicals were strong for Georgia-Pacific and PPG Industries.

In the photographic industry, both Eastman Kodak and GAF report strong chemical operations in 1979 while soaring silver costs hurt photographic profits.

Possibly the company with the most to thank chemicals for is U.S. Steel. The company's restructuring in its core operations cost it an $808.6 million pretax write-off in the fourth quarter, producing an earnings deficit for both the quarter and the year. However, chairman David M. Roderick says, "Operating income for the nonsteel business segments improved significantly, with chemicals showing the most improvement." For 1980, U.S. Steel expects seven major chemical projects, started up in late 1979, to reach full production capability early in the year.

With such results, essentially nonchemical companies cashed in on chemicals' unexpectedly good year in 1979. The fourth quarter kept up the financial steam with some exceptions in auto- and housing-related products.

For 1980, there are few signs yet that chemical producers are being dragged into a spreading recession. However, the year's uncertainty is high, and no one expects a repeat of 1979's gain soon. □

R&D gets heavy emphasis in West Germany

In addition to generous funding by chemical firms, there is unique and constant interaction among industry, its leaders, and universities

Dermot A. O'Sullivan
C&EN, London

Geist, geld, geduld, und glück! Brains, money, patience, and luck! This is how Paul Ehrlich, considered the "father" of chemotherapy, summed up the four essential elements needed for success in research.

The sentiment holds as true now as it did at the turn of the century when the late German Nobelist said it. The result today is a chemical R&D establishment in West Germany unique among the world's chemical industries.

Heavily funded—more so than in the U.S. by relative measures, highly stable, and strongly growth oriented, R&D at West German chemical firms has an added distinction of close ties to universities. The latter characteristic contrasts with weakening academic-industrial ties in chemical research in the U S.

One comes away from discussions with West German chemical industry leaders with the distinct impression that the future of the industry is bright. Despite the much-emphasized concern over such problems as rising raw material costs and the growing threat of bulk commodity organic chemicals becoming available from so-called developing countries, established producers promise to override these issues through technical ingenuity and creative skills.

Measured by any parameter, global R&D spending patterns of the three largest West German ("Big Three") chemical companies—BASF, Bayer, and Hoechst—are impressive. Between 1969 and 1978, the latest year for which data are available, Bayer doubled its R&D spending worldwide to more than a billion deutsche marks (about $564 million at the 1978 conversion rate). For both BASF and Hoechst, 1978 R&D spending was more than two and a half times what it was in 1969—$459 million for BASF, $593 million for Hoechst.

Too, over the past 10 years, the degree of spending every year outpaced that of each preceding one. The rise was unswerving, regardless of whether sales, or, more significant, net profits rose or fell. Again from 1969 to 1978, the average annual rate of increase was 11.5% for BASF, 8.1% for Bayer, 11.3% for Hoechst.

Last year was no exception and outlays went up a further notch. Estimated R&D investment by BASF in 1979 was $523 million, on the basis of last year's conversion rate. Bayer's was $654 million, and Hoechst's was $656 million.

As a percentage of world sales, total R&D spending has remained remarkably constant. For BASF, it averaged about 3.5% of annual sales each year during the past 10 years. For Bayer and Hoechst, the average was closer to 4.5%.

When gauged against global net profits, however, the R&D spending pattern was quite different. BASF averaged 131% of net profits annually over the past 10 years, Bayer 167%, and Hoechst 188%. But these averages mask the percentage swings. For example, for Hoechst, the variation moved from a low of just under 100% of the 1969 worldwide net profit figure to a remarkable 343% in 1977. The reason for the variation, of course, is that whereas net profits rose and fell from year to year, the R&D spending increase was maintained.

Karl Heinz Büchel, director of research at Bayer in Leverkusen, observes: "In absolute figures, when one extrapolates against the inflation rate, other international chemical concerns show a leveling of their R&D effort. We don't have this up to now."

It's obvious, too, that members of the corporate management boards of BASF, Bayer, and Hoechst maintain a long-range view when assigning money to R&D each year. Annual funding has remained immune to annual variations in net profits.

"R&D spending is not cyclical here," says Horst Pommer, research director of BASF in Ludwigshafen.

Adds Klaus Weissermel, his counterpart at Hoechst in Frankfurt: "Our general strategy is to continue our research effort and to have independence whether business is excellent or not. Research efforts are more and more important for the future. And to achieve success, research needs time. So it should not be interrupted."

C&EN staff photo

Buchel: no leveling in R&D effort

Büchel, Pommer, and Weissermel are full members of the executive boards of their respective companies. When the annual budgets come up for discussion and debate, they have understanding listeners, since a preponderance of their fellow board members are chemists too. For that matter, the boards' chairmen—Herbert Grunewald at Bayer, Rolf Sammet at Hoechst, and Matthias Seefelder at BASF—themselves are chemists of international repute and with long company experience behind them.

BASF's approach to drawing up its R&D budget is somewhat similar to the approach that Bayer and Hoechst take. "We have a central planning department here in Ludwigshafen," Pommer explains. "This ties together all the company's operational activities and plans.

"In the course of the planning procedure, there are three planning periods. One is a strategic plan covering a period of roughly 10 years or more. The second is a five-year plan. The third is the first year of the five-year plan, the budget year. R&D, of course, plays its role in this whole planning procedure.

"We review the five-year plan each year and make adjustments if necessary. This plan is drawn up by the heads of each of the company's 20 divisions together with the people from R&D. Within each field of company activity, the corresponding divisional heads and the research people with something to say meet to discuss single or group projects.

"One member from central research sits in on these divisional meetings. This results in a very close contact between the divisions and the work at central research."

Peter Haug, who is responsible for planning, coordination, and control of research for BASF, adds: "Each division within BASF is responsible for production, marketing, and product development of its range of products. The division head covers that spectrum. The R&D people bring in the research side."

Day-to-day management of R&D has become increasingly complex as the companies have expanded. BASF, Bayer, and Hoechst now are truly international chemical companies with wholly owned affiliates in most of the major West European countries and as far afield as Japan and the U.S. The larger of these affiliates have their own research staffs and R&D projects. But the reins of control remain firmly in the hands of the managers at corporate headquarters in West Germany.

"There are two situations here, the easy ones, and those that are less easy," Büchel points out. "The easy area is where the activities of a foreign affiliate match those of one of our domestic divisions. Chemagro, the agrochemicals arm of Mobay Chemical in the U.S., is a good example. Work there is very closely coordinated with our agrochemicals division here in West Germany. You find this, too, between Miles Laboratories [in the U.S.] and our pharmaceutical division.

"Another example is Cutter Laboratories in Berkeley, Calif., acquired in 1974. That was a real diversification for Bayer. Cutter is doing research in serum fractions, blood plasma infusions, and other health care products for human and veterinary use. It now is fully integrated into the strategy of our pharmaceuticals division.

"The less easy situation is when the affiliate is in a completely different line of business. Agfa-Gevaert is one example. We don't have any direct research activity in photography here in the main Bayer company."

Büchel chairs a commission that seeks to harmonize the R&D activities of the nine company divisions, the affiliates, and those of the central corporate research facilities. The commission meets every three months to evaluate the aims and progress of what is being done.

About 44% of Bayer's annual R&D budget is spent by affiliates, 41% by the divisions, and the 15% balance by the corporate research facilities. These include a central R&D labo-

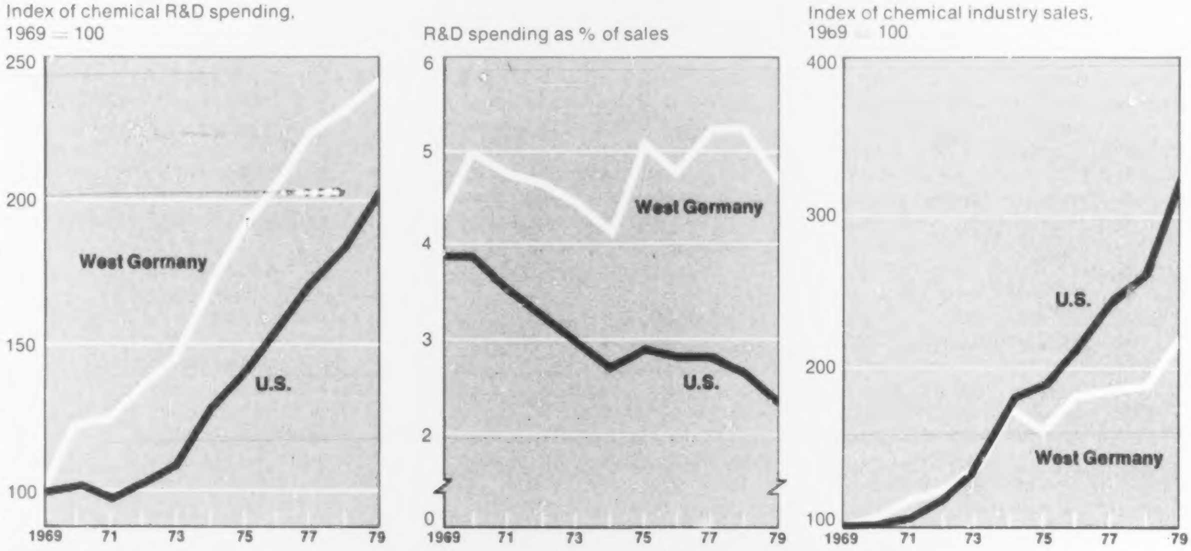
West German chemical R&D support relatively greater than in U.S.

Support for research and development by the West German chemical industry greatly outstrips R&D funding by U.S. chemical companies as a percentage of sales or profits. In addition, over the past decade, relative West German R&D support has held up much better than in the U.S. Even absolute R&D spending figures have grown faster in West Germany than in the U.S. This has occurred despite the considerably higher U.S. inflation rate.

Specifically, R&D spending by the West German chemical industry was about 4.9% of sales in 1979, about double the 2.4% rate of the U.S. basic chemical industry. One factor in the high West German percentage may be relatively more drug research than in the U.S. However, a more important factor may simply be the consistency in the West German percentage over a decade when the figure fell sharply in the U.S.

U.S. R&D managers point out that U.S. inflation tends naturally to pull down U.S. R&D spending as a percentage of sales, since inflation in front of cost has outrun inflation in R&D. However, the same reasoning could apply to some extent to R&D spending in West Germany.

The higher U.S. inflation rate, reflected in a higher growth rate for chemical sales in the U.S., might actually push up U.S. R&D spending faster than in West Germany. But it hasn't. While basic chemical companies' R&D support in the U.S. has about doubled in the past decade, R&D support in West Germany's chemical industry has gone up nearly two and a half times over this period.



Sources: Verband der Chemischen Industrie, C&EN calculations

Sources: Verband der Chemischen Industrie, C&EN surveys

Sources: C&EN survey of 17 major U.S. basic chemical companies, Verband der Chemischen Industrie ratory and an applied physics department.

Corporate research entails long-term, fundamental studies that aren't division-oriented. At the same time, more than half the work at the central research facilities is undertaken for the divisions. "This prevents corporate research from becoming an ivory tower," Büchel remarks. "People are kept practically oriented and maintain their expertise in applied chemistry."

The viable and dynamic nature of the chemical industry entails the need for continually evaluating the direction that R&D efforts should take. "It is important that we achieve a good mixture of 'young' and 'old' products," Hoechst's Weissermel points out. "One goal of each of our 15 divisions is to maintain a product mix. This is part of our daily work."

Pommer at BASF offers much the same line of thinking. "We are going more into fine chemicals and specialty products. On the other hand, it would be very dangerous for BASF to neglect the base chemicals and concentrate only on the sophisticated chemicals."

Apart from the changing pattern of product research, studies on new or improved processes are taking a larger slice of the R&D pie than in the past. Weissermel observes: "There is continuing need for processes that work as effectively as possible with respect to energy use, raw materials, and ecological considerations. In general, process-oriented work dominates in those areas involving bulk products."

Biotechnology is a relatively new area of research on which BASF, Bayer, and Hoechst are putting increasing emphasis. "In the past, biotechnology studies at Hoechst centered on classical fermentation techniques to produce antibiotics," recalls Weissermel. "Now we have switched to new fermentation methods. We started with single-cell proteins. We will explore what can be done with naturally occurring resources, how they might be converted to chemicals in general."

Bayer's Büchel says, "We will definitely intensify our research efforts in this area. Bayer already does this through Miles Laboratories where we are one of the largest citric acid producers from starch. There is a link between biotechnology and the aim of the chemical industry to switch to renewable resources. It also holds the potential of saving energy because high temperatures and high pressures aren't required."

Interest is growing, too, in genetic engineering. "We are doing some work at Miles," Büchel says. "And we are setting up a unit in the biochemistry department of our pharmaceutical division."

Hoechst, however, is most enthusiastic about the future prospects of genetic engineering. It sees it as a natural outgrowth of the company's long involvement in the production of insulin from animal glands.

"Based on this experience, it was decided about 20 years ago to establish a synthetic peptides group," explains Günther Seidl, head of Hoechst's pharmaceutical research. "The main object was to do some insulin synthesis studies. We have since acquired important background knowledge on hormonal regulation by peptides, and a better understanding of endocrinology and peptide chemistry."

More recently Hoechst scientists have turned their attention to genetic engineering. "Our first objective was to produce insulin," Seidl says. "Using a strain of *Escherichia coli*, we have achieved gene expression and isolated a product that behaves immunologically like insulin. We are also studying interferon production. We have had some success already, but we still have a long way to go to achieve production in commercial quantities."

Hoechst's Weissermel admits, "It will take time, of course. But this is normal when you begin in any new field. Our hope is that some of our future synthetic workers will be bacteria."

E. coli aside, there is a changing pattern in the qualifications of scientists being hired by the R&D departments at BASF, Bayer, and Hoechst. Chemists still are in high demand. But a greater proportion of people are being sought with expertise in other disciplines such as microbiology, physics, electrical engineering, and computer science.

Close connections with university scientists is one of the distinguishing features of the West German chemical industry. It has a long tradition, going back to the early days of organic dyes development more than a century ago.

On an industrywide scale there is the Fonds der Chemischen Industrie. This is a fund that all the country's chemical companies pay into. The money is used mainly to aid the work of university professors and to further chemical education.

"The Fonds der Chemischen Industrie is a marvelous thing to have," says Hans Bock, chairman of the Institute of Inorganic Chemistry at Frankfurt University. "It is essentially nonbureaucratic and the funding is very straightforward."

Pommer: ad hoc collaboration is best

But in addition to the fund, there are other ways whereby university people, especially those of professorial rank, get financial support from the chemical industry in West Germany. One is through a system of contracts. Each contract is arranged on an individual basis between the company and university professor, and may extend for a few months or for several years. The company pays a stipend that the professor can accept whether or not he or she gets a grant from the fund.

Bock, 1975 recipient of the Frederic Stanley Kipping Award in organosilicon chemistry administered by the American Chemical Society, and recent developer of a special technique for gas-phase analysis of heterogeneously catalyzed reactions, points out that there usually are no strings attached to the arrangement of direct company funding. The professors apply the money to further their research. It need not have any direct bearing on the commercial emphasis

Weissermel: goal is good product mix

of the company providing the money.

Those who get such research grants are free to publish their findings. There is a tacit understanding, on the other hand, that should a discovery emerge of direct interest to the sponsoring company, then that company is given first option to evaluate it. If it is patentable, the company pays the costs of drawing up the documents and filing them, but the professor is listed as the inventor. "This may lead to a delay in publication of six months or a year from the legal standpoint," Büchel says, "but it is in the professor's ultimate best interests."

In addition, there are, of course, consultancy contracts between chemical companies and university professors. Under the terms of such contracts, specific company research problems are discussed.

Pommer notes that BASF has no consultancy agreements as such. The approach Pommer favors is what amounts to "ad hoc" collaborations. These might last six months or a number of years, depending on the circumstances. He is highly selective of those he seeks to collaborate with. "We choose them on the basis of what they are working on, not the university they are associated with," he says. "We know personally some 50 or 70 professors who not only are good friends of ours but who do highly sophisticated work. We talk to them about our problems, and they talk to us about theirs. It's a case of give and take."

There are other ways in which West German academics may get material assistance from the large chemical companies. Frequently the companies supply chemicals that either are expensive or difficult to obtain. Occasionally, a company will undertake physical or chemical analyses, that call for highly specialized equipment, on compounds made in university labs.

The flow of this kind of cooperation is by no means unidirectional. There are times when a company may seek the help of someone at a university who is an authority in a particular area. "Chemical industry innovations increasingly are interdisciplinary events," Büchel points out. "It can happen that an industrial R&D department may not have the broad spectrum of expertise needed at a particular time in a research program."

He stresses, however, that "we are not trying to manipulate universities by bringing very highly specialized work to them. We don't believe it is good to burden universities with special problems of industry. This is a general philosophy [on which] we in industry speak with one voice."

For their part, research managers in the chemical companies realize the advantages to them of maintaining good relations and an open avenue of communication with the country's foremost professors of chemistry. They realize, of course, that these professors attract the keenest students. And it is no coincidence that many of these bright graduate students ultimately find a place in the R&D department of industry. "In return for our support of professors' research, we hope at least to get an early offer of their good students," Büchel admits.

Adds Pommer, "From our collaboration programs we get an idea of the potential of the people who might be good for us." He notes that practically all the young people who join BASF with a degree in the natural sciences come directly from universities. "Only about 1 or 2% of them come to us from other companies," he says. "We don't advertise openings in our R&D department except in the pharmaceutical field where we need specialists."

Lecture and teaching programs further strengthen the bond between the West German chemical concerns and the universities. All of the corporate directors of research, and most in the top echelons of R&D management, have professorships in leading universities, as, indeed, do the board chairmen of BASF, Bayer, and Hoechst. Such continuing involvement in academic life is something unique for West Germany.

"The natural sciences faculties of our universities like to have industry people on their teaching staffs," Büchel says. "It's not just for honorary reasons. They are aiming at an additional teaching contribution from the applied side. Particularly in chemistry, there are some areas where industry has more or less a monopoly position on knowledge."

These assignments aren't taken lightly. Büchel holds a professorship at Aachen University's chemistry department. He lectures there frequently on such diverse topics as agrochemicals, pharmaceuticals, and the place of heterocyclics in commercial products. He also deals with broader issues, such as the future of raw material and energy resources, biomass, and the like. As part of the course, the students are invited to visit Bayer's chemical complex at Leverkusen where they have the opportunity to view first hand practical aspects of the subjects dealt with in the lectures. "All this exposes students to the realities of industrial life," he remarks.

BASF's Pommer, who has an honorary professorship in organic and applied chemistry at Braunschweig University, has lectured on the synthesis of vitamins and fine chemicals, describing the role of research in a large chemical concern. "Many of my BASF colleagues do this," he says. "The aim is to bring to the attention of young students and professors some ideas about what industry is doing in chemical research."

Weissermel of Hoechst has an appointment at Braunschweig University, too. He gives about six double-hour lectures each year as part of the regular chemistry course there. "It takes a lot of time," he admits. "It's not just a case of giving a few lectures, but the many hours required for their preparation."

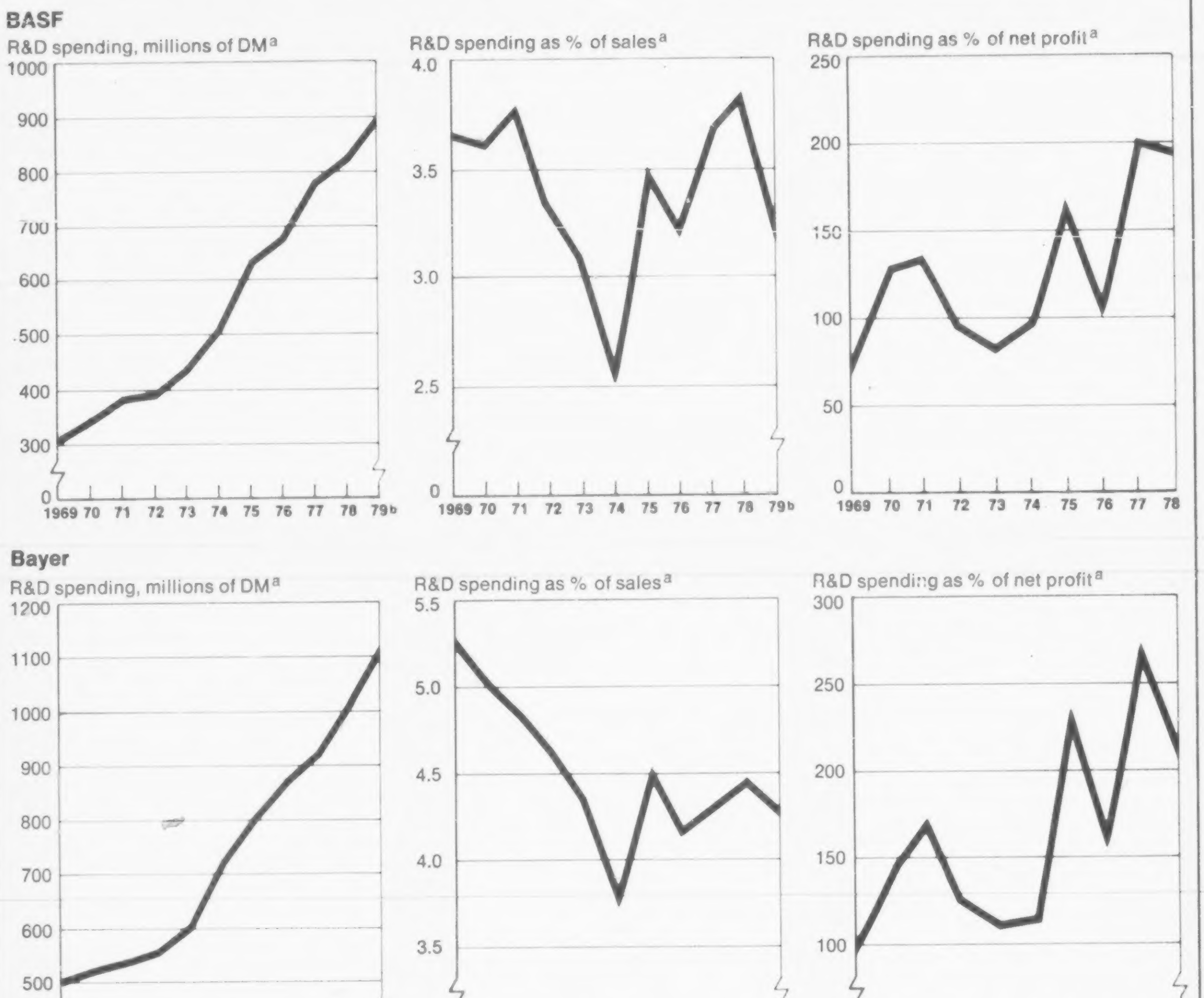
According to Weissermel, more than 25 of Hoechst's senior scientists are lecturing at universities. "We don't want to compete with the professional academics," he says. "What we teach is applied research so that people can come to a better understanding of what this entails. We also touch on some of our problems and methods we use to solve them in an industrial environment. We wish to open the eyes of students and professors to the solving of practical problems."

Weissermel's involvement in chemical education matters goes still deeper. For the past six years he has been president of the Fonds der Chemischen Industrie. One of its functions is to grant funding to high school and university chemistry students. And he chairs a commission of the Gesellschaft Deutscher Chemiker (West German Chemical Society) that plans the content of refresher courses for those who have graduated from university five or more years previously.

When the need arises, companies send some of their chemists back to universities for training in specialized techniques, particularly in the analytical field. "They stay for about six months," Pommer notes. "But BASF does not have sabbatical leaves as such."

Hoechst, on the other hand, does have a sabbatical leave policy. Right now several company scientists are spending some time in the U.S. Two are in Washington, D.C.—one at the National Institutes of Health's department of metabolic diseases and the other familiarizing himself with atmospheric chemistry research and analysis at the National Bureau of Standards. Two others are at the University of California Medical Center in San Francisco. There, one is acquiring fundamental techniques in genetic engineering; the other is

R&D spending is increasing for West Germany's three major chemical firms



a Worldwide. b Estimate. **Note:** $1.00 = 1.72 DM, Dec. 31, 1979.

Group channels funds from chemical industry to education

"The Fonds der Chemischen Industrie [Chemical Industry Fund] is a unique organization," asserts Burchard Ording, executive director at its administrative headquarters in Frankfurt. "It is not only unique to this country, but no other industry branch here has a similar body."

The fund falls within the organizational structure of the Verband der Chemischen Industrie (Chemical Industry Association). It channels financial support from the West German chemical industry to students and chemistry teachers throughout the country's high schools, technical colleges, and universities. It awards annual cash prizes in certain fields of chemical excellence, compiles data, and publishes a variety of literature. And it continues to play a role in helping shape the country's science education policies.

The management board of the fund has 15 members. Ten are corporate directors of research in companies, five are university professors. Klaus Weissermel, head of chemical research at Hoechst, is the current chairman.

It was established in 1950 at a time when West Germany's postwar chemical industry and education system were in dire need of reconstruction. It set out with two primary objectives. One was to readapt the country's basic research to international standards. The other was to foster greater emphasis on the natural sciences in general and on chemistry in particular in the higher educational system.

Three men did much to shape the organization at the outset. One was W. Alexander Menne, board member for research at Hoechst and president of the verband at the time. Another was Theo Goldschmidt, a prominent West German chemical industrialist. The third was Otto Bayer, board member for research at Bayer and the fund's first chairman.

The first order of business of the early founders was to generate capital for the fund. They adopted a formula that imposed a monthly levy of 0.50 DM per employee for every chemical company in the country. This "fee" has risen to 1.85 DM (about $1.10 at the current exchange rate) per month for every worker. Last year, 7.7 million DM ($4.53 million) was obtained.

The funding formula is being revised. Future company contributions will be keyed to annual sales rather than to the number of employees. For every 10,000 DM ($5880) in sales, companies will pay 1.20 DM (71 cents) to the fund. The reason for the switch, Ording explains, is that the number of workers in West Germany's chemical industry has declined somewhat in the past few years and likely will remain static for the next several years. Meanwhile, inflation is putting a squeeze on the fund's financial resources.

C&EN staff photo

Ording: a unique organization

Some of the Chemical Industry Fund's money provides scholarships for students and teachers who want to take a higher degree in chemistry. The fund awarded some 4800 such scholarships between 1951 and 1979. Last year alone the number was 80.

Grants also are made to about 1200 professors doing chemical research at universities. The only criterion for awarding research grants is that the individuals be regarded by their peers as capable of making significant contributions to the science. The specific nature of the research isn't a factor in the decision. The work might be in a highly academic and specialized field of no apparent relevance to the practical world of the chemical industry. On the other hand, it also could center on a topic like polymerization or catalysis having a direct bearing on the industry.

Chemists who receive research grants from the fund may use the money as they see fit for their studies. They may even apply it against the cost of travel in connection with their work. Grants aren't intended to go toward purchase of equipment, however. Such purchases, Ording notes, should be made from their university budgets.

A research grant can vary from about 4000 DM ($2400) to 45,000 DM ($26,500). The amount given usually spreads across a two- to three-year period.

When the project for which the money is received is completed, the researcher usually provides the fund with an account of the work and the findings, together with any publications that might arise from it. But there is no obligation that this be done.

Grant applications aren't made directly to the fund. Instead, a grants committee appointed by the fund's management board decides who should get financial help. There are five such committees covering biochemistry, inorganic chemistry, organic chemistry, physical chemistry, and macromolecular and technical chemistry combined. Each committee comprises five experts in the particular field drawn from universities.

"The fund is very selective in making scholarship and research grants," Ording says. "There is a great deal of deliberation to ensure that the money goes to those most worthy of getting it. The object is to sponsor the very talented people, consequently, the number of awards made each year to highly qualified postgraduates is fairly small."

The fund also awards cash prizes annually. One, for 10,000 DM ($5900), goes to a person who has made an outstanding contribution to chemical literature. Five prizes go to university teachers under 40 years of age judged to have done some original chemical research.

The fund issues a variety of publications aimed at specific "target groups," as Ording puts it. The material is compiled by experts in industry and universities selected by the fund. Ording's staff coordinates its preparation.

One publication details chemical research in West German universities. It also lists professors and staff members there. It appears every five years or so.

The fund also prepares guides for high school chemistry teachers. These consist of slides and manuals giving technical information on latest developments in topics such as petrochemicals, polymers, corrosion research, and the like. "One of the aims is to provide chemistry teachers with concrete up-to-date examples of the chemical industry at work," Ording says.

A series of brochures is issued periodically, mainly for students considering studying in chemistry. These deal with such topics as the kind of work and job prospects in the industry, what managers look for when recruiting, and highlights of chemical research sponsored by the fund.

Besides promoting the advancement of West German chemistry, Ording says that the fund continues to have an increasing influence on the development of the country's university education policies. And indications are that it will continue in this role in the future. "We frequently are called on to give advice to various legislative bodies in the field of higher chemical education," he says.

Chemists chair boards at three largest West German chemical companies

Chemical companies in West Germany have a preponderance of scientists among their top executives. At the three largest companies—BASF, Bayer, and Hoechst—chemists rank prominently on their senior boards of management.

For instance, 10 of BASF's 11-man board of executive directors have doctorates—six of them in chemistry, one in chemical engineering, two in engineering, and one in economics. At Bayer, 11 of the 13-member board of management have doctorates—six in chemistry, one each in engineering, physics, and medicine, and two in law. At Hoechst, among the 14 members of the management board are nine with doctorates—five of them in chemistry.

Moreover, BASF, Bayer, and Hoechst are unusual among the major international chemical firms in that their chairmen rose from the ranks of the companies through chemical research and production. Somewhat unusual, too, is that they have spent their entire professional careers in the companies they joined some 30 years ago.

Matthias Seefelder, 60, chairman of BASF's executive board, is regarded by his colleagues and his peers as "a chemist's chemist." Like many West Germans his age, his studies were interrupted by the war. He entered the University of Munich in 1947 and emerged in 1951 with a doctorate in chemistry. His research there centered on diimide chemistry.

He moved to Leverkusen, where he went to work in BASF's central research laboratory. He undertook pioneering research on intermediates for the production of vitamins A and E, as well as in the field of dyes chemistry. Seefelder was appointed head of BASF's dyes laboratory in 1962 soon after it was created. Five years later, he moved out of the laboratory into management as head of the dyes division.

In 1973 Seefelder was elected a full member of BASF's executive board. His responsibilities centered mainly on expanding the company's production and business outside West Germany, including coordinating activities in Eastern Europe. He succeeded Bernhard Timm as chairman in 1974.

Herbert Grunewald, 59, chairman of the board of management at Bayer, began his chemical studies at Frankfurt University but later enrolled at the University of Heidelberg. He received a Ph.D. degree there in 1956. His research included studies on the synthesis of cane sugar and on valonea, an extract from acorns used in tanning.

Grunewald joined the chemical intermediates department of Bayer in Leverkusen the same year. Ten years later he became department manager with the added responsibility of running the company's organic chemicals analysis laboratory and its central organics pilot plant.

Grunewald was appointed to Bayer's board of management in 1968. Soon after, he became directly involved in coordinating the company's worldwide activities when Bayer underwent a major corporate restructuring. He became chairman in 1974.

Rolf Sammet, 60, chairman of Hoechst's board of management, became involved in chemistry as an outgrowth of his interest in photography. He studied at Stuttgart University and obtained a Ph.D. degree there in 1945 for research in inorganic chemistry.

In 1949 he joined Hoechst, then part of the I.G. Farbenindustrie combine in the solvents laboratory, several years later moving to the company's technical directorate. There he was in charge of organizing and restructuring the synthetic fibers division. When Hoechst expanded in polyester fibers, he was made head of the fibers operations at Bobingen, near Augsburg.

Following seven years as head of Hoechst's technical directorate in Frankfurt, Sammet was appointed to the board of management in 1964. He was responsible for plastics film activities and also was director of Hoechst's extensive manufacturing complex just outside Frankfurt. In 1969, he succeeded Karl Winnacker as chairman of the management board.

associated with the department of gastroenterology.

"Frankfurt is their base," comments research director Weissermel. "But don't forget, Hoechst is an international concern. We believe it is helpful for the future to establish good personal contacts in different places with people who are leaders in their fields and who are at the forefront of new disciplines."

There are instances, too, in which West German professors go to the chemical companies to learn. "This is particularly the case in the area of chemical engineering at universities," Pommer points out. "One needs firsthand knowledge of operating large equipment, high-pressure apparatus, and the like.

"Those who are invited to BASF for such training are highly selected. While with us, they work on special company projects. We promote this because the professors, through the knowledge they gain, are in a better position to give the right kind of lectures to their students. And the industry needs good chemical engineering graduates from the practical standpoint. We have had three or four such people with us recently. Indeed, at one time, the present minister of education for Hamburg spent two years at BASF on a training program."

Company scientists have the opportunity to attend a number of lectures throughout the year. There are, of course, general lectures, many arranged through local sections of the Gesellschaft Deutscher Chemiker. But there are also special lectures available to selected groups within the companies.

"Invitations are not limited to West Germans," Weissermel notes. "Speakers come from other countries, too. They represent a major cross section of prominent scientists. The object is to keep our people well informed on what's going on, to learn of others' research, get updated on new disciplines and new methods. But this is not specifically a Hoechst activity. It's the same for comparable companies like BASF and Bayer."

There is one activity in which BASF alone engages. This is an annual summer program for chemistry graduates. There are two three-week courses at the company's Ludwigshafen headquarters. Morning lectures are given by high-ranking company people. In the afternoons, there are visits to plants on the site.

Each program is open to 60 students. About half of them come from countries outside West Germany, in some instances from as far afield as such countries as Turkey and the Soviet Union.

"While here, they get detailed information about BASF," explains Pommer, who heartily endorses the program. "They learn not only about chemical problems, but about chemical engineering and financial and personnel matters. The aim isn't so much to hire future staff but to inform chemistry students in a very special way about the chemical industry.

"We are anxious to inform these people who later may become our partners either in other companies or in government positions. If they know about the work of the company, we hope they will understand it better," he says. ☐

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Sulfuric and phosphoric acids face strong year A Key Chemicals Review Page 10

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TOOTH DECAY

A preventable disease Page 30

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Cover: Section of a decayed human tooth viewed by polarizing microscope. Yellow region is partially demineralized area below the enamel surface. Blue-green region is the intact enamel. Photo courtesy of Leon M. Silverstone of the University of Iowa college of dentistry

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Prosperity continues for big-volume acids

Sulfuric acid demand grows faster than forecast and phosphoric acid pushes limits of capacity; prices for both acids are increasing

Even with a number of uncertainties, 1980 is shaping up as another banner year for the big-volume U.S. mineral acids—sulfuric and phosphoric. Production will be up. Price increases might do more than just pass through inflated materials and energy costs. And prospects for capacity expansions will brighten.

Two strong forces produce the sunny outlook for these acids—another good market year for U.S. fertilizer, the dominant end product, and a boost from exports. Exports are being watched closely by the U.S. government, which must approve any large-scale phosphate product shipments to the Soviet Union. But to date, no shipment of such product has been blocked.

The fertilizer prosperity in 1979 and 1980 continues its pattern over the past 15 years of appearing late in the overall U.S. business cycle. Trailing the general business expansion, fertilizer tends to hit its stride toward the end and sometimes, as in 1974 and 1975, carries right into the following recession. This year, fertilizer could do it again, if forecasts of a recession in the U.S. in the second and third quarters prove correct.

For phosphoric acid, capacity limitations actually will hold down sales expansion. Currently, phosphoric acid plants are being used at rates above normal limits.

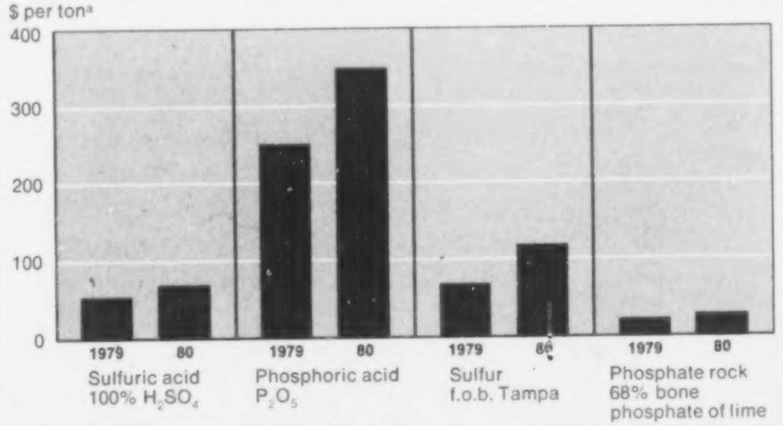
Sulfuric is being produced below full capacity use nationwide. However, at some locations, such as major phosphoric acid sites in southern Florida, sulfuric acid production is close to capacity.

Such good times are not without problems, not the least of which is still questionable profitability. Certainly, price increases at the beginning of 1980 following others during 1979 have pushed contract selling prices for these acids way above year-earlier levels. But these price increases often have not covered cost increases. Much of the price increases for big-volume acids reflect added fuel costs.

With such value jumps, the big acids are a giant business. These acids could have a total production value exceeding $7 billion in 1980—more than $3 billion for sulfuric acid and nearly $4 billion for phosphoric acid. Sulfuric acid is the largest-volume chemical produced in the U.S., and phosphoric acid is ninth largest.

Yet, few chemicals are actually as cheap per ton as these acids. At the high side of the current contract price range, sulfuric acid costs just 3.5 cents a lb. Phosphoric acid costs about five times as much but is still among the less expensive major chemicals.

Prices have shot up for the big acids and their raw materials



a First quarter of each year; long tons in the case of sulfur.

The low cost of sulfuric acid relative to its valuable properties as a powerful acidulator or catalyst makes it one of the better values among industrial products. As a result, sulfuric acid is one of the most widely used chemicals, but its dominant outlook is for making phosphoric acid.

Phosphorus' importance in growing crops lies behind the unprecedented demand for phosphoric acid. This property also leads to the major uncertainty this year in demand. So far, in spite of the political effects on export potential, fertilizer exports have shown no significant drop. Nor has U.S. demand slackened in the face of rising fertilizer prices and uncertainties about sales volume of feed grains.

But with such strong demand for phosphoric acid, why aren't there more capacity expansions? Partly because producers remember the most recent big round of capacity expansion, which ran into a sudden slowing of phosphate fertilizer sales. A producer shakeout followed in the mid-1970's. Producers may not yet want to take a chance on major investment.

As with most other large-volume chemicals, plants for these acids must be large and complex to be most economical. Typically, a sulfuric acid plant feeds a nearby phosphoric acid plant that feeds a nearby derivatives plant. A relatively small part of the total material fed to the complex comes out as product. Materials-handling equipment for phosphate rock and unwanted coproducts account for a large share of the cost of fertilizer complexes.

The large-scale operation of a phosphoric acid plant accounts for a large part of the relatively high value added in phosphoric acid compared to raw material phosphate rock. Among starting materials, phosphate rock typically makes up only 20% and sulfuric acid 33% of the final product cost.

For additional details of the outlook for these two major-volume mineral acids, see the following pages.

Bruce Greek, Houston

Key Chemicals

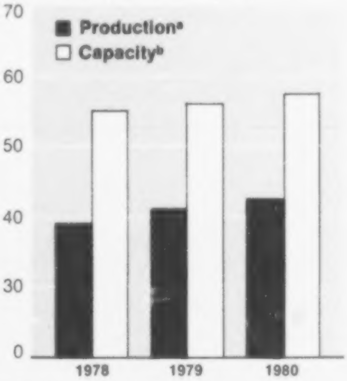
H_2SO_4

Sulfuric acid

- ***Demand improving***
- ***Capacity growing***
- ***Prices rising***

PRODUCTION/CAPACITY

Millions of tons, 100% H_2SO_4



a From all sources. b First quarter.

HOW MADE

Elemental sulfur burned to the dioxide, oxidized to trioxide, and reacted with water; sulfur dioxide recovered from nonferrous metals smelting, oxidized to trioxide, and reacted with water

MAJOR END USES

Fertilizers 65%, chemical manufacture 5%

FOREIGN TRADE

Exports—less than 100,000 tons per year, imports—less than 400,000 tons

PRICES

Posted contract prices $65 to $75 per ton as 100% H_2SO_4

COMMERCIAL VALUE

$3 billion for total production, 1980; $2.5 billion, 1979

The workhorse of the chemical industry, sulfuric acid, is getting more and more expensive because it is being fed more expensive "oats," that is, sulfur. Price escalations for sulfur are being passed along rapidly by sulfuric acid producers, who have pushed up their prices roughly a third in a year's time.

Yet these prices in no way seem to reduce demand for sulfuric acid. When all the 1979 statistics are in, production of sulfuric acid may have topped 41 million tons, an increase of 4%. Such an increase, although not so large as in 1978, still was more than many industry observers forecast for 1979.

Some sources believe that 41 million tons might be too low an estimate for 1979 production. A top level for production might be 41.5 million tons for 5.5% growth.

For 1980, forecasts for sulfuric acid output carry provisos for the uncertain U.S. economic situation and export unknowns in phosphoric acid and phosphate fertilizers. The forecast range for production runs between just over 41 million tons for a 1% gain to 44 million tons for a 7% gain.

Sound reasoning underlies both the low and high forecasts for 1980 production. The low forecast takes into account a moderately severe U.S. recession, a small cutback in U.S. fertilizer use, and a loss of exports of phosphoric acid and derivatives to the U.S.S.R.

The high-side forecasters are impressed by the boom in sulfuric acid's main market, phosphate fertilizer. After a good farm year in 1979, U.S. fertilizer production and consumption could be up substantially in 1980. Both U.S. use and exports are likely to help fertilizer demand. So far, any U.S. recession, if there is one, has not affected other major use areas of sulfuric acid such as petroleum refining, although growth in these uses remains small.

Even if production of sulfuric acid in 1980 reaches 44 million tons, nameplate plant capacity of 57.5 million tons as of the first quarter will not be strained. Something over 1 million tons of annual capacity is estimated to have been added during 1979 based either on elemental sulfur or on by-product smelter gases. More capacity, mostly through debottlenecking, will be added during 1980. However, the new capacity total will be small, perhaps about 300,000 tons.

If production of sulfuric acid in 1980 reaches the midpoint of the forecast range, capacity use will be about 75% of the nameplate total. This is a bit more than recent rates but still well below the top rates of the mid-1960's, which reached 95%.

Most of the new capacity based on elemental sulfur and a large part of the new smelter-acid capacity will go to make phosphoric acid and its derivatives for use in fertilizer. In 1980, about two thirds of U.S. sulfuric acid production will go to make fertilizers. This use pattern is the reverse of 20 years ago, when fertilizer took one third of a much smaller sulfuric acid output of about 17 million tons.

Even with its large-volume position among uses of sulfuric acid, phosphate fertilizer has one of the larger growth rates, about 5% in 1980. Small use areas such as copper leaching or processing of uranium or vanadium ores might have larger growth rates, but their base is tiny compared to that of fertilizers.

Fertilizer use of sulfuric acid is expected to continue to grow faster than will fertilizer production. The reason is that the quality of phosphate rock acidulated to make phosphoric acid is trending down. That is, to make the same quantity of phosphoric acid from lower-quality rock, more sulfuric acid will be needed. The exception would be if new technology for beneficiating the rock as it is mined proves more economical than added use of sulfuric acid in phosphoric acid plants. Resolving this issue probably will take a decade or more.

Because of slippage in phosphate rock quality, chances are small that consumption of sulfuric acid in 1980 will drop. A more than modest gain seems assured even with fast-increasing acid prices rising in line with prices of raw material sulfur.

If demand for derivative phosphate fertilizer continues strong, a bit of market juggling may result. Fertilizer exports probably will have to slow down during the U.S. planting season this spring but perhaps will be made up later, the government willing in some cases. None of this would hurt sulfuric acid.

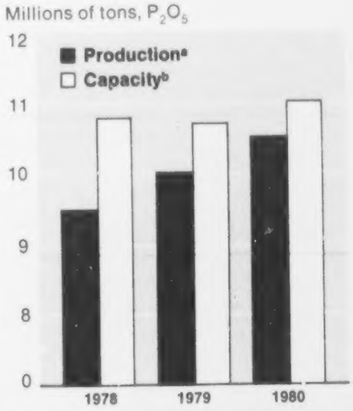
Key Chemicals

H_3PO_4

Phosphoric acid

- ***Demand strong***
- ***Capacity expanding***
- ***Prices rising***

PRODUCTION/CAPACITY



a Includes wet-process and furnace acids.
b First quarter.

HOW MADE

Reaction of phosphate rock and sulfuric acid, burning of phosphorus and reaction with water

MAJOR DERIVATIVES

Ammonium phosphate 60%, superphosphate 20%

MAJOR END USES

Fertilizer 80%, detergents 5%

FOREIGN TRADE

Exports—could exceed 1 million tons as P_2O_5; imports—very small

PRICES

\$350 per ton (100% P_2O_5) for fertilizer use, other grades up to \$550

COMMERCIAL VALUE

\$3.8 billion for total production, 1980; \$3.0 billion, 1979

In 1979 farmers found that phosphoric acid derivatives in fertilizers, the dominant market, were in tight supply and had high prices. There is no new twist for 1980—tight and dear is still the rule for phosphoric acid and products made from it.

Producers of phosphoric acid by the main "wet" process (reacting sulfuric acid with phosphate rock) generally are pushing their plants at capacity, if not a bit over. The production rate hit another record in December 1979 at 880,000 tons of P_2O_5, equivalent to an annual rate of 10.6 million tons, according to the Fertilizer Institute.

This production rate can't be sustained for 1980, several industry sources say. But the actual rate could come close if new capacity in 1980 runs well and no feedstock problems develop. Probably a combined total of about 10.5 million tons (P_2O_5) of wet-process and furnace acid will be made during 1980. Of this, about 9.9 million tons will be wet-process acid. Something under 700,000 tons will be furnace acid, as this process's slow production decline continues.

Capacity for wet-process acid has begun to expand again after a five-year pause. The pause followed an almost disastrous jump in capacity in 1974–75 coupled with slack sales growth. A small amount of new capacity came on stream in 1979, bringing nameplate capacity to about 9.6 million tons (P_2O_5). This year another 500,000 to 600,000 tons should start up.

Furnace acid nameplate capacity is flat at about 1.4 million tons a year (P_2O_5). Use of this capacity has dipped under 50% recently. As production of this type of phosphoric acid declines further, some capacity may be shut down. However, all of it is old and the original investment has been fully returned. Hence there is an incentive to run these plants as long as demand remains for the high-grade acid product and as long as the elemental phosphorus raw material isn't needed in making something else.

Longer-term, if these old plants disappear, there should be no real problem for consumers of high-grade acid. Technology has been developed and is being refined to produce very-high-quality phosphoric acid by purifying the standard lower-quality wet-process acid.

In sum, total domination of phosphoric acid production by wet-process technology is coming. Even now, wet-process variables are the key to phosphoric acid supply.

Wet-process acid production is becoming slightly more difficult each year. The problem is a gradual decline in the average phosphorus content of remaining U.S. phosphate rock. The decline is the result of using the best-quality rock first as the most economical and then going to lower-quality supplies.

As rock quality declines, phosphoric acid plant capacity declines. More rock must be processed to produce the same quantity of phosphoric acid. More sulfuric acid is required. More by-product gypsum is produced. And more material moving through the plant adds costs in energy, equipment, and labor. Excluding all other costs, such as energy, the increase in material throughput alone will cause prices of phosphoric acid and its derivatives to rise continuously over the long term.

Capacity expansion then could be less than the figures show and certainly more expensive. Debottlenecking will help preserve capacity, but new units will be needed eventually. These units will cost substantially more because of their increased size for the given capacity.

To pay for incremental expansions and new plants, profits from phosphoric acid and derivatives should increase, producers say. So far, most producers are getting proportionate coverage of cost increases in selling price increases. This isn't hard with all wet-process plants operating at capacity.

Even so, producers are concerned about buyer resistance this spring in the face of large increases in fertilizer prices. Resistance is expected to stiffen as farmers find out some of their other cost jumps this year, notably for diesel fuel.

Despite these fears, fertilizer producers have no choice but to pass along their large cost increases for phosphoric acid. In turn, phosphoric acid producers hope to pass along their own cost increases and a bit more. If they ever had a chance to do this, it is now.

Canadian chemicals post solid gains in 1979

Strong fourth quarter caps year of dramatic growth in sales and earnings for four major firms; profit margins more than doubled from 1978

All of Canada's four largest publicly reporting chemical companies—Canadian Industries Ltd. (CIL), Celanese Canada, Du Pont Canada, and Union Carbide Canada—were in pretty good shape at the end of 1979.

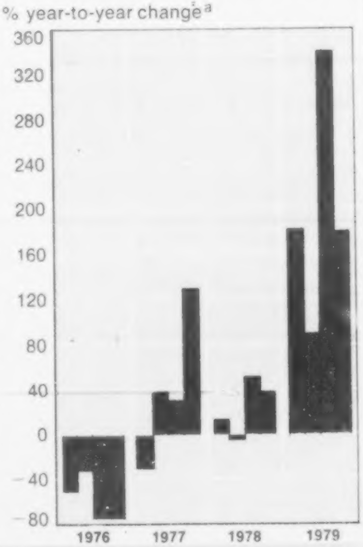
Big new plants and a favorable feedstock situation have made Canada a significant contender in world petrochemical markets; exports are booming. Sales and earnings reached record heights. But there's some concern that business will level off in 1980.

Combined fourth-quarter sales for the four companies amounted to nearly $743 million (Canadian), a 23% increase from fourth-quarter 1978. Combined earnings, excluding extraordinary items, rose to $51.4 million, 178% higher than in the 1978 period. For all of 1979, sales increased 26% from 1978 levels, to $2.8 billion. Net income totaled $174 million, a 175% gain. Profit margins, overall, increased by a factor of about 2.2.

CIL fourth-quarter sales were $219 million, a 20% increase from the like period in 1978. Ordinary net income came to $7.0 million, up 94% from a year earlier. For the full year, sales rose 18% from 1978 to $880 million. Net income amounted to $36.3 million, a 38% increase. However, CIL's net for the fourth quarter and the year was sweetened by a $12 million extraordinary gain from the company's sale of its interest in a real estate development venture.

Among the four companies, CIL continues to be the leader in sales (just barely) but the laggard in profitability. Return on sales was 3.1% for the fourth quarter and 4.1% for the year, compared to 2.0% and 3.5% in the respective 1978 periods. Performance was adversely affected by a long strike at International Nickel, a major CIL customer and supplier.

Fourth-quarter earnings reflect continued recovery



[a] After-tax earnings of four largest publicly reporting Canadian chemical companies—Canadian Industries Ltd., Celanese Canada, Du Pont Canada, and Union Carbide Canada.

Combined earnings of four firms rose 175% in 1979

$ Millions (Canadian)	Net sales 1979	Change from 1978	Net income 1979	Change from 1978	Profit margin[a] 1979	Profit margin[a] 1978
Canadian Industries	$880.0	18%	$36.3[b]	38%	4.1%	3.5%
Celanese Canada	353.6	22	21.2[c]	221	6.0	2.3
Du Pont Canada	879.6	33	59.0	478	6.7	1.5
Union Carbide Canada	685.9	30	57.8	188	8.4	3.8
TOTAL	$2799.1	23%	$174.3	175%	6.2%	2.8%

[a] Net income as percentage of sales. [b] Excluding extraordinary gain of $12.0 million. [c] Excluding extraordinary loss of $3.0 million.

Celanese Canada's fourth-quarter sales came to $99 million, up 19% from the fourth quarter of 1978. Net income for the period was $5.5 million, a 62% increase. But that figure was reduced to $2.5 million by a $3 million write-off of remaining goodwill in discontinued polyester fiber operations. Sales for the year totaled almost $354 million, a 22% increase from 1978. Net income (excluding the extraordinary loss) reached $21.2 million, 221% higher than in 1978. Profit margins also improved substantially; 5.6% for the fourth quarter and 6.0% for the year, compared to 4.1% and 2.3% in the like 1978 periods.

Du Pont Canada likewise showed healthy improvement. Sales for the quarter amounted to $233 million, a 25% increase from the 1978 period. Net income was $18.5 million, a more than ninefold increase from an admittedly lackluster fourth quarter in 1978. For the year, sales reached $880 million, a 33% increase from 1978. Net income climbed to $59 million, up 478% from the preceding year. Profit margins were 7.9% for the quarter and 6.7% for the year, compared to only 1.0% for the quarter and 1.5% for the year in 1978. Du Pont attributes much of the improvement to strong export sales, which rose 49% from 1978 levels.

Union Carbide Canada, which was in decline during much of 1978, continued the turnaround that began in last year's fourth quarter. Carbide sales for the fourth quarter of 1979 totaled $192 million, a 23% increase from the fourth quarter of 1978. Earnings rose to $20.4 million, up 113% from the 1978 period. For all of 1979, sales amounted to $686 million, 30% ahead of 1978. Net income rose 188%, to $57.8 million.

The company is still the most profitable of these four companies. Return on sales was 10.6% for the fourth quarter and 8.4% for the year, compared to 6.2% and 3.8% in the corresponding 1978 periods. Carbide says the earnings gain resulted largely from strong domestic and international demand for petrochemicals. This strong demand allowed prices to recover from the depressed levels of the preceding three years.

Ward Worthy, Chicago

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Chemical & Engineering NEWS

March 3, 1980

Growing number of companies install mutagenicity testing labs Page 10

U.S.-Soviet Technology Exchange

Afghanistan changes the rules Page 35

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Chemical & Engineering NEWS

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Cover: St. Basil's cathedral in Moscow. Photo by Marvin Ickow/Uniphoto

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Corporate political activity on the rise

More than 700 corporate political action committees have been set up since 1975; candidates received $9.8 million from them in 1977–78

Political Action Committees (PAC's), organizations put together to raise funds for political candidates, are playing an increasingly larger role in financing federal election (particularly Congressional) campaigns. During 1974 the average candidate for a House seat received $10,500 from PAC's; by 1978 that figure had increased to $28,000. In the same period the number of PAC's increased from 722 to 1653.

Most of this phenomenal growth can be traced to a ruling by the Federal Election Commission in early 1975 that made it clear that corporations, as well as labor unions and trade associations, could establish and administer PAC's. And corporations were not slow to take advantage of the ruling. At the end of 1974 there were only 90 corporate PAC's. By the end of 1978, corporations had established 808 PAC's, some 20 of which were sponsored by chemical companies. By comparison, the number of labor union PAC's increased only 16 to a total of 217, whereas the number sponsored by trade, membership, and medical associations increased 133 to a total of 451.

PAC's operate by soliciting voluntary contributions from their employees, stockholders, and members. Currently PAC's can contribute up to $5000 to a candidate for each election (primary, runoff, or general). However, the House has approved a bill, now in conference, that would limit PAC contributions to $3000 per election for House races, and prohibit House candidates from receiving more than $70,000 from all PAC's, during any two-year election cycle. The limits on how much a Senate candidate could receive would not be changed. PAC's can also make nonmonetary contributions to a candidate's race, such as sponsoring mass mailings.

The sponsoring organization cannot give money to a PAC for political contributions, but it can allocate money to cover administrative costs of the committee. Each PAC must register with and report to the Federal Election Commission, which monitors all receipts, disbursements, and contributions to candidates running for federal office. Funds left over at the end of any two-year election cycle can be carried over into the next cycle.

Though corporate PAC's account for more than half of all PAC's, they are far from being the largest money raisers for political candidates. That honor goes, according to a study by the Business Roundtable, to those sponsored by medical and other membership organizations. For the two-year election cycle beginning in January 1977 and ending in December 1978 such organizations collected $25.2 million and contributed $11.5 million to federal candidates. Labor PAC's raised $19.8 million and con-

Dow accounted for 31% of chemical firm PAC's spending during 1977–78

			Contributions to candidates				
			Senate		House		
Company	Receipts	Disbursements	Democrat	Republican	Democrat	Republican	Total
Dow Chemical	$202,628	$191,625	$5,140	$34,250	$25,050	$77,040	$141,480
FMC	90,168	92,437	8,000	18,600	23,000	38,550	88,150
Monsanto	78,111	76,755	7,000	13,000	20,200	16,550	56,750
Olin	47,764	60,740	4,250	11,508	4,975	12,801	33,534
American Cyanamid	41,984	26,752	2,250	13,175	2,925	6,646	24,996
Siauffer Chemical	29,229	29,795	1,000	14,300	1,600	12,395	29,295
Allied Chemical	18,824	16,735	2,650	5,450	1,900	4,400	14,400
Borg-Warner	17,494	7,009	0	3,171	900	2,900	6,971
Ethyl Corp.	16,589	11,300	5,500	4,000	2,500	1,050	13,050
Borden	16,462	5,212	150	2,100	800	2,150	5,200
Celanese	16,403	15,300	700	4,050	4,700	5,600	15,050
Diamond Shamrock	14,704	9,150	500	3,250	700	2,700	7,150
Cabot Corp.	12,885	10,275	1,000	4,325	2,450	2,100	9,875
PPG Industries	12,704	12,200	1,000	9,600	200	600	11,400
Hercules	10,757	12,225	200	3,600	1,600	5,000	10,400
Ciba-Geigy	10,697	6,400	900	800	1,450	3,050	6,200
Goodyear	9,364	5,200	500	2,700	100	1,500	4,800
Rohm & Haas	7,131	6,700	0	0	0	2,250	2,250
W. R. Grace	5,239	4,800	1,000	800	1,100	900	3,800
B. F. Goodrich	4,060	0	0	0	0	0	0
TOTAL	**$663,197**	**$600,610**	**$41,740**	**$148,679**	**$96,150**	**$198,182**	**$484,751**

Source: Federal Election Commission

N-Nitrosamines

ACS Symposium Series No. 101

Jean-Pierre Anselme, *Editor*
University of Massachusetts

A symposium presented at the Eighth Northeast Regional Meeting of the American Chemical Society.

Fear of human exposure to known carcinogens and mutagens in the workplace, in the environment, and in consumer products (foods, cosmetics, pharmaceuticals, and pesticides) has triggered a dynamic interest in *N*-nitrosamine chemistry.

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tributed $10.3 million. Corporate PAC's raised $17.7 million and contributed $9.8 million.

Some $21.5 million in PAC funds went to Democratic candidates, with labor unions providing 45% of the total. Medical and other membership associations accounted for 23%; corporations, 16%; the Democratic Party, 8%; and nonaffiliated PAC's, 8%. As might be expected, of the $19.8 million given by PAC's to Republican candidates, labor unions supplied only 3%; medical and membership associations supplied 32%; corporations, 30%; the Republican Party, 23%; and nonaffiliated groups, 12%.

One half of a per cent of all PAC's accounted for nearly one quarter of all contributions made by these organizations in 1977–78, the study found. The 10 largest PAC contributors to federal candidates (excluding the Democratic and Republican parties themselves) were sponsored by membership groups or labor unions.

The American Medical Association led the list of the five largest contributors with $1.6 million. It was followed by the National Association of Realtors, $1.1 million; National Automobile Dealers Association, $975,675; United Auto Workers, $964,465; and the AFL-CIO, $920,841. The largest corporate PAC contributor, sponsored by International Paper Co., gave $173,056.

Dow Chemical, by far the most enthusiastic chemical company sponsor of PAC's, was not far behind. FEC records show that Dow has set up eight PAC's.

Dow is also by far the most successful of the chemical companies at fund raising. In the 1977–78 two-year election cycle, the Dow PAC's raised a total of $202,628 and contributed $141,480 to federal candidates. Altogether, PAC's sponsored by the 20 chemical companies (not including primarily drug or oil companies) raised $663,197 and contributed $484,751. Their contributions are likely to be greater in the future since many of the PAC's were established as recently as 1978, and more are likely to be established as the 1980 elections draw nearer.

The pattern of chemical company PAC contributions closely follows that of other corporate PAC's. Democratic candidates received slightly more than 28% of chemical company PAC contributions, and Republicans got the remaining 72%. Senate candidates got 40% and House candidates 60% of the contributions. For all corporations, the Roundtable study shows, Democrats received 35% of the contributions, Republicans 65%, Senate candidates 35%, and House candidates 65%. □

Federal Alert—
new legislation

This report lists legislation introduced between Jan. 22 and Feb. 20. Senate and House bills are listed under subject area by bill number, primary sponsor, and the committee(s) to which referred.

SENATE

Authorization. S. 2240—Cannon (D.-Nev.). Sets NASA's fiscal 1981 budget ceiling at $5.7 billion; referred to Commerce, Science & Transportation.[a]

S. 2320—Cannon (D.-Nev.). Sets NBS's fiscal 1981 budget ceiling at $87.7 million; referred to Commerce, Science & Transportation.[a]

Energy. S. 2202—Weicker (R.-Conn.). Cuts imports of petroleum and its products from OPEC immediately at least 30%; referred to Finance.

Research. S. 2234—Stevenson (D.-Ill.). Requires persons, organizations conducting recombinant DNA research, not supported by NIH funds, to notify Secretary of Health & Human Service of their activities; referred to Labor & Human Resources.

Transportation. S. 2245—Cannon (D.-Nev.). Prohibits Interstate Commerce Commission from wholesale removal of operating restrictions on motor carrier industry; referred to Commerce, Science & Transportation.

HOUSE

Authorization. H.R. 6495—Price (D.-Ill.). Sets DOD's fiscal 1981 RDT&E budget ceiling at $16.6 billion; referred to Armed Services.

Energy. H.R. 6260—McCormack (D.-Wash.). Provides $20 billion for accelerated fusion energy RD&D program; referred to Science & Technology.

Health. H.R. 6377—Daschle (D.-S.D.). Provides presumption of service connection for occurrence of certain diseases in veterans who were exposed to agent orange; referred to Veterans Affairs.

Patents. H.R. 6533—Railsback (R.-Ill.). Establishes uniform federal patent procedures for universities, small businesses; referred to Judiciary.

Science. H.R. Res. 487—Brown (D.-Calif.). Calls for restrictions on U.S.-Soviet science exchanges for one year; referred to Foreign Affairs.

H.R. 6521—Wampler (R.-Va.). Establishes National Science Council to decide questions of scientific fact that arise in agency proceedings to regulate chemical substances; referred to Agriculture, Interstate & Foreign Commerce, Science & Technology.

H.R. 6556—Traxler (D.-Miss.). Would allow National Medal of Science also to be awarded for contributions in social and behavioral science; referred to Science & Technology.

Space. H.R. 6304—Brown (D.-Calif.). Sets goals and policies for civilian space program; referred to Science & Technology.

[a] Administration bill.

U.S.-Soviet technology trade outlook chilly

Invasion of Afghanistan promises significant cutbacks in sales of know-how and technological products; Third World problems are seen as next theater of confrontation

Wil Lepkowski
C&EN, Washington

For the past several weeks, ever since the Soviets invaded Afghanistan and the Carter Administration cut off grain sales and then the export of high technology to the Soviet Union, a debate has been rising in Washington over how much U.S. technology should be flowing to the Soviet Union.

New policies are bound to emerge once the Administration completes its review of a "post-Afghanistan" technology policy toward America's ideological adversary. Some companies, such as Occidental Petroleum, Dow Chemical, Control Data Corp., and others who trade directly with the U.S.S.R., say the U.S. will be hurt more than helped by the ban on trade. Others say all efforts to aid the Soviet economy should cease because the Soviet Union is the U.S.'s sworn enemy.

Just what the review will say is impossible to determine now. But more restrictions on a broader range of products, processes, and know-how are expected. Last week's embargo of Occidental Petroleum shipments of phosphate to the U.S.S.R. could be a harbinger of tough new controls. Even a curtailment of technical activities between universities is expected.

Says deputy assistant Defense secretary Ellen L. Frost, "We are devoting more attention to the Soviet learning curve in advanced technology. Imports from the West may supply crucial learning experiences which permit an overall advance in Soviet capabilities. We don't know how to measure this 'ripple effect,' but it is safe to assume that it is there and the Soviets place great value on it."

Whatever controls are established, it is obvious that technology policy toward the Soviet Union encompasses issues that go far beyond weapons-system diversion. In chemical technology alone, the issues range from help in enabling the Soviet Union to produce chemical warfare weaponry to the general effect of chemical process control on raising industrial productivity.

Even the unrestricted flow of research on chemical thermodynamics is helping the Soviets establish more refined theories to guide their version of social evolution. That, of course, isn't, shouldn't, and anyway couldn't be stopped. But it is part of the picture, too.

Détente was the guiding spirit behind the rich volume of technology transfer until Afghanistan caught it short. It began in the middle 1960's when the Soviet Union made an important decision bearing on its central goal of burying capitalism. It determined that science and technology would be the fundamental force in the struggle. However, Soviet leaders knew they would have to learn from the West how to manage technology. For the key to commanding technology was management, and those skills lay mainly in the U.S. with its management information systems.

That was why détente—an advanced form of peaceful coexistence—came into being. Technology was to be its kingpin. Arms control was to be the safety device for keeping the capricious Americans off the nuclear trigger. America, many analysts say, bought détente without really understanding what the U.S.S.R. was up to. U.S. policy leaders naively saw it as an opportunity to convert the Soviet Union to capitalism.

So just as President Franklin D. Roosevelt established the Export-Import Bank to finance Soviet-U.S. trade in the 1930's, the Nixon Administration led by Secretary of State Henry Kissinger launched technology transfer negotiations between U.S. corporations and the Soviet Union. Soviet ministers were allowed into corporate boardrooms and made privy to the most cherished capitalist secrets. By 1973 a U.S.-Soviet Trade Council was established and technology-borne détente was really winging.

Two technologies were emphasized: computers and chemicals. A modern chemical plant is the essence

Brady: Illegal transfers were costly

C&EN staff photos

Perry: guidelines don't need revision

U.S. exported some innovative chemical technology to Soviets during the 1970's

Product	Typical product uses	Year of contract	Process and/or raw materials	Features
Acetic acid	Acetates for textiles, computer tapes	1973	Low-pressure process using methanol and carbon dioxide	Low-pressure process considered significantly better than earlier processes. Uses highly selective catalyst system and provides high yields. As of January 1976, license granted to six companies worldwide with manufacturing capacity of almost 1.3 million metric tons. Process termed "best in world" by Soviet trade official
Ammonia	Fertilizers, explosives, refrigerants, nylon, nitric acid, and acrylonitrile	1969–71 1973–76	Catalytic reaction of nitrogen from air with hydrogen obtained from high-pressure reforming of hydrocarbons (usual source is natural gas)	Plants characterized by large single-train installations that employ centrifugal compressors, an integrated energy system, and improved catalysts. Process permits sharp reductions in investment and production costs compared to earlier processes. Unit inputs of electric power, water, and manpower substantially reduced. Half of world's ammonia in 1977 may have been produced in plants using this technology
Butadiene	Synthetic rubber, nylon fibers, and resins	1970	One-stage dehydrogenation of butane (Catadiene process)	Uses large-capacity reactors, turbocompressors, and automated control system. Installation purchased by U.S.S.R. reportedly was largest "Catadiene" plant in the world, with annual production capacity of 90,000 tons of butadiene. Soviets claim the one-stage process permits a 40% reduction in unit investment and production costs and at least doubles labor productivity compared to the existing two-stage process
***p*-Xylene**	Polyester fibers, films, and resins	1976	Separation of *p*-xylene from mixed xylene feedstocks by continuous, selective adsorption. Uses fixed bed of solid adsorbent	Claims include increased yields, reduced investment and production costs. Process minimizes corrosion
Polyethylene (high-density)	Pipe, film, wire and cable, food and beverage containers, shipping drums	1974 1977	Gas-phase process for manufacture of high-density polyethylene from ethylene. Fluidized-bed reactor is used	Licensor claims savings of 25% in capital investment and 15% in operating costs, compared to the most efficient competing processes (November 1975). No solvents or dispersants are required as reactant carriers, thus reducing pollutants

Source: Central Intelligence Agency

of efficient technological management and the Soviets wanted that know-how as well as a strong share of future chemical export markets. (Watchful critics of the process were reminding the uncommitted that Hitler also had known chemistry's importance and thus secured the German chemical cartel I. G. Farben to pour its global technological and financial resources into building a war economy.)

Computers were important for obvious reasons. Microprocessors, of course, run modern chemical plants and the Soviets wanted that knowledge. But computers were related to everything else as well, from military command and control systems to the management of an entire economy. Economic management was the main reason the Soviets wanted so much to buy computer hardware and technology from Control Data Corp.

Americans were happy to sell (trade was almost out of the question because the Soviets, until they built their western-designed chemical industry, had almost nothing comparable to sell in return) and the Soviets were more than happy to buy because such technology would keep world communism right on target.

In chemicals, the Soviets established a deft policy. Knowing their country lacked enough hard currency to pay for the buildup of a western-style chemical industry, Soviet leaders on the State Committee for Science & Technology negotiated a buy-back policy in return for the financing. They would secure loans from western financial institutions to construct chemical plants and, to repay those loans, "sell" the products back to those firms.

That policy, for example, was the keystone of the currently controversial 1973 agreement between the Soviets and Armand Hammer's Occidental Petroleum. Hammer would ship the Soviets superphosphoric acid fertilizer, and would receive Soviet ammonia made in western-built and -financed plants. As a bonus to the Soviets, their agriculture also would be helped.

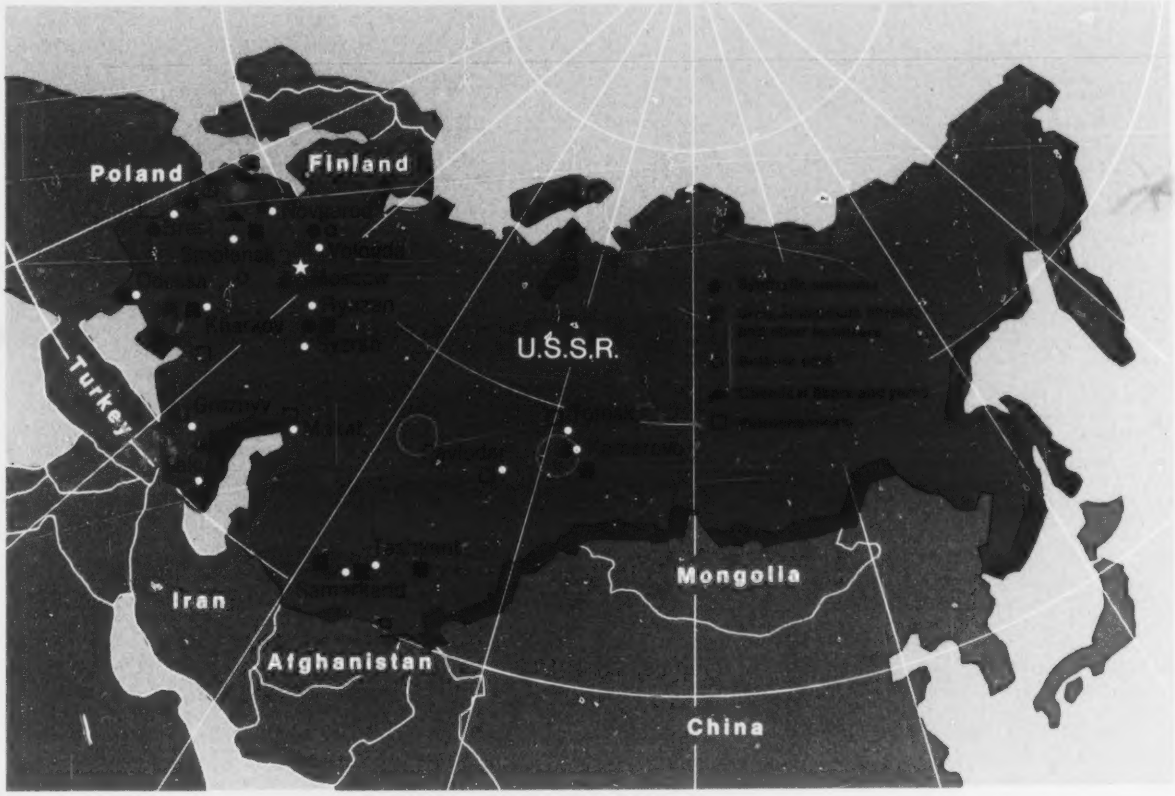
But nothing works perfectly for anyone, not even those who play the Soviet brand of geopolitical/technological chess. Détente began breaking down in the summer of 1978 over Soviet squelching of scientific dissidents. And it currently lies shattered because of the invasion of Afghanistan. Now, Soviet and U.S. strategists are rethinking everything. A Cold War mentality has returned and the time is being used here and there to find out how to think about technological relations in a world on the brink of economic, political, and raw materials chaos.

The consensus on both sides is that détente has not been working out too well for either side. For those Soviet leaders who were always skeptical of too much ideological idealism and who emphasize power politics, détente only meant opening the U.S.S.R.'s society too widely to western contamination. For U.S. skeptics, giving U.S. technology meant not only strengthening the economy of an adversary but the risk of diverting that technology to arms. Afghanistan demonstrated their worst fears and now there are vengeful second thoughts.

Indeed, testimony over the past three weeks by former acting director of Export Administration, Lawrence Brady, revealed substantial diversion of U.S. technology into Soviet military machinery. Brady says that because he tried to alert Commerce Department superiors to lax enforcement of the Export Administration he was forced to resign.

In testimony before the Senate Armed Services Committee early last month, Brady asserted, "The illegal

Many major Soviet chemical plants were built with western technology



transfer of the technology has given such an advantage to the Soviet Union that it will require hundreds of millions of dollars of additional expenditure by the federal government even to begin to overcome the technical advantages which the Soviet bloc has acquired."

He went on to criticize the "unregulated transfers of technical data" between U.S. corporations and Soviet technical ministries during the height of détente, when reporting the details of transactions was not required. "In certain instances," he says, "some firms have been willing to make short-term profit at the expense of the long-term interests of our nation."

The nexus of the debate is not really whether all trade should stop. Most of the debate is over what should go from the West to the Soviet Union, especially since U.S. allies enthusiastically sell sophisticated products to the Soviet Union. There are extensive lists of restricted items that the Coordinating Committee (CoCom)—made up of North Atlantic Treaty Organization countries—has drawn up. To sell such items requires exceptions. Part of the government's review of export policy includes a review of the CoCom list.

Undersecretary of Defense William J. Perry says the CoCom guidelines do not appear to need revision. But the President is reviewing proposed new guidelines for computers and some probably will be made more restrictive. Also, he says, new restrictions on technical data packages, computer software, process know-how, and technical support will be prepared. Some "critical materials" used in the manufacture of "advanced technology defense products" probably will be restricted, too.

But what of U.S. corporations? Evidence is clear that those that have signed agreements with the Soviets have a lot to lose if technological détente is shifted midstream.

"Practically everyone feels that this is not the time to promote trade," says one highly placed corporate official. "But what I imagine will happen is that after our election, and after their Party Congress, there will be another try at coexistence because there will be a new leadership. I'd look for a significant upsurge of interest again, assuming of course that the Soviets stop where they are."

Kempton Jenkins, president of the Soviet-U.S. Trade Council, says he hopes the Administration doesn't throw the baby out with the bath water. "The question is whether our policies will drive the Soviets back to autarchy and decelerate their engagement in the economic process. Whatever action the U.S. might take in the Afghanistan crisis, it is my hope that it will not be contrary to our own best interests.

"The Soviet natural gas resources in Siberia, which are almost impossible for the Soviets to develop unilaterally, could be of great importance to the energy-consuming western world in the decade ahead. It offers a great opportunity to promote interdependence. They would depend on the natural gas earning for hard currency while we would only be marginally dependent on the Soviet Union for natural gas."

Jenkins, who has to work with his Soviet counterparts in the Trade Council, has to choose his words with care. But by virtue of his position, it is clear he is a true believer in the concept of interdependence articulated by one of his mentors, former U.S. ambassador to the Soviet Union, Llewellyn Thompson. Said Thompson, "We're going to lure, seduce, draw the Soviets out of their society because their consumer appetites can't be suppressed. It's not going to be an ideological thing, ever."

Kellogg and Air Products lead U.S. firms in chemical engineering assistance to U.S.S.R.

Location	Product	Capacity (metric tons)	Completion	Contractor(C)/Licensor(L)/ Engineering(E)
Angarsk	Benzene	120,000/year	1979	Air Products (C)
Angarsk	Ammonia	1500/day	1980	Kellogg-Toyo-U.S.S.R. (L,E,C)
Caucasus	Benzene	100,000/year	1980	Air Products (C)
Cherepovets	Ammonia	1500/day	1979	Kellogg (L), Toyo (E)
Drogobych	Ammonia	1500/day	1979	Kellogg (L), Toyo (E)
Gorlovka	Ammonia	1500/day	1979	Creusot-Loire and Kellogg (C)
Grodno	Ammonia	1500/day	1979	Kellogg (L), Toyo (E)
Mozyr	Benzene	125,000/year	1981	Air Products (C)
Novgorod	Ammonia	1500/day	1979	Kellogg (L), Toyo (E)
Novomoskovsk	Ammonia	1500/day	1979	Kellogg (L), Toyo (E)
Odessa	Ammonia	1360/day	1979	Kellogg-Ensa-U.S.S.R. (L,E,C)
Perm	Ammonia Urea	1360/day 1500/year	1979	Kellogg (L), Toyo (C)
Perm	Ammonia	1500/day	1980	Kellogg-Toyo-U.S.S.R. (L,E,C)
Polotsk	Benzene	125,000/year	1981	Air Products (C)
Rossosh	Ammonia	1500/day	1979	Kellogg (L), Toyo (E)
Ryazan	Benzene	125,000/year	1981	Air Products (C)
Ufa	Linear alcohols	48,000/year	1980	Conoco (L), Foster Wheeler-Speichim (E)
Ufa	Benzene-xylene	125,000/year	1980	Technip (C), under construction by Procon International

Source: *Oil & Gas Journal*

Pro-Soviet-trade people see the need to review export control decision-making. But to cut off all trade would be disastrous for foreign policy and bad for the U.S. economy. Trade with the Soviets, they say, strengthens everyone. Commerce is neutral. Selling the Soviets grain, for example, was draining the Soviets of $2 billion in hard currency. It was helping build no war machine. The same reasoning was used by Occidental in justifying the sale of phosphoric acid to the Soviet Union.

One analyst who couldn't disagree more with the "mutual advantage" line of thought is Michael Dean of the Advanced International Studies Institute in Bethesda, Md. That institute specializes in studies of East-West strategic affairs and systematically follows Soviet policy. He says U.S. policy makers are too easily fooled by the Soviets through a form of wishful thinking that never takes account of what Soviet leaders say.

"All we have to do is read their speeches," he says. "They haven't changed one bit. There's nothing that could possibly lead us to believe that Brezhnev doesn't mean exactly what he says. When Defense Secretary Harold Brown said in his recent statement that we can't possibly know what Soviet intentions are, that was the prime example of this blindness. We have convinced ourselves that the Soviets cannot tell us the truth."

The key to understanding Soviet thinking, on technology in relation to everything else, has to do with a systems perspective that goes under the term, "correlation of forces." Analysts Dean, John J. Ford, and the Library of Congress' Joseph Whelan, as well as others, have explained it. In brief it is an interrelated compendium of six elements seen in context of the global evolution of communism: military, science, technology, economy, politics, and philosophy. The Soviets factor them all and decide when the time is ripe to advance.

"The problem we face in foreign policy," says Mark Miller of Systems Planning Corp. of Arlington, Va., and author of a study on the role of western technology in Soviet strategy, "is that we don't have a very good view of history or a conceptual framework, whereas the Soviets do. That is why our foreign policy is so capricious." Miller believes that Henry Kissinger's view of détente as pulling the Soviets slowly into an inextricable tie with the western economic system was misguided and uninformed.

"We tend to look at peaceful coexistence in its cooperative aspects," Miller points out. "The Soviets see it more in its competitive relevance. Soviet trade with the West has been the same since Peter the Great—to strengthen the basic sinews of national power, the military power of the state."

They still have the quest for universalism, adds Dean, still have the same geopolitical objectives as the czars, still are a police state, still an autocracy, still paranoid and suspicious (only more so), still self-righteous, and still need to spread the "true faith," which now is to rid the world of capitalism.

To Miller and Dean, the U.S. has to tell them it knows what they're up to, that it will do nothing to help them in their quest, directly or indirectly, and tell them that it is willing to risk war with them. Those are terms they understand, and never mind the consequences of nuclear war.

But that train of thought overreaches the scope of this article. Neither system has global nuclear war in its equation, although the Soviets are said by intelligence experts to be better prepared internally for any such eventuality. Their view is that the U.S. is more capricious than the U.S.S.R. in pulling the nuclear trigger.

There is an important "fringe" group of international technological observers whose views need to be noted for a complete scan of how technology, finance, capitalism, and communism interact worldwide. This is the "conspiratorial" school whose main spokesman is Antony C. Sutton, formerly of the Hoover Institution. Sutton wrote a three-volume work on U.S. technology transfer to the Soviet Union since the Bolshevik Revolution. Thus, his subsequent thoughts deserve a little airing.

Sutton's ideas are in his latest book, "Wall Street and the Bolshevik Revolution." To him, Wall Street (banks and corporations) have long been working together to lock up the world's wealth and subject the world's peoples to an orderly, humanistic, but totalitarian world government.

Sutton calls his book a story reflecting the betrayal of the Russian Revolution. "The tsars and their corrupt political system were ejected," he says, "only to be replaced by the new powerbrokers of another corrupt political system. Where the U.S. could have exerted its dominant influence to bring about a free Russia, it truckled to the ambitions of a few Wall Street financiers who, for their own purposes, could accept a centralized tsarist Russia or a centralized Marxist Russia but not a decentralized free Russia."

Sutton today lives in Arizona and publishes a newsletter that monitors financial political involvement around the world. But his views are generally rejected by the Millers and the Deans. Lawrence Brady, a former official in the Commerce Department's Export Administration, thinks the U.S. has been selling the Soviets

U.S. chemical exports to U.S.S.R. are worth almost twice imports from U.S.S.R.

First nine months 1979	Volume	Value ($ thousands)
U.S. EXPORTS TO U.S.S.R.		
Phosphoric acid, 65% or more P_2O_5	427,500 tons	$71,056
Cellulose compounds	17,024,920 lb	9,263
Ammonium compounds	108,928 lb	2,044
Industrial varnishes	677,224 gal	2,033
Plastic and rubber film and sheet	55,113 lb	1,718
Phosphoric acid esters	2,319,139 lb	1,606
Silicon	42,119 lb	1,245
***n*-Butyl alcohol**	4,502,573 lb	1,201
Calcium hypochlorite	2,162,659 lb	1,151
Chemical mixtures nec[a]	1,631,181 lb	1,081
Phosphoric acid, less than 65% P_2O_5	8,267 tons	951
Resorcinol	650,409 lb	942
Ethylene glycol	4,411,996 lb	760
Diagnostic reagents	na	577
Preparations, blood- or cardiovascular-related (human use)	na	559
Halogenated cyclic hydrocarbons	486,714 lb	455
Nonsteroid preparations	na	407
Manganese oxides	1,824,150 lb	296
Industrial paints	25,597 gal	287
Magnesium compounds	2,204,600 lb	279
Formaldehyde	551,650 lb	251
Vaccines, veterinary	na	219
Antibiotics, antineoplastic agents, agricultural pesticides	1,782 kg	210
Arsenic compounds	39,462 lb	199
Color lakes and toners	67,293 lb	176
Inorganic compounds nec[a]	85,046 lb	176
Drugs containing radioactive isotopes	47,502 millicuries	$175
Putty	24,238 lb	151
Synthetic organic chemicals nec[a]	33,000 lb	150
Acyclic organics nec[a]	105,000 lb	144
Veterinary biologicals nec[a]	na	130
Catalysts nec[a]	232,123 lb	130
Nitrogen compounds nec[a]	156,332 lb	128
Prepared culture media	4,394 lb	122
Laboratory reagents	1,189 lb	108
Inorganic acid esters	5,500 lb	89
Phosphorus compounds nec[a]	23,404 lb	85
Interior trade sale emulsion paints	7,000 gal	84
Perfumes	na	75
Aluminum compounds	53,970 lb	66
TOTAL EXPORTS VALUE		**$91,516**
U.S. IMPORTS FROM U.S.S.R.		
Ammonia	na	38,559
***p*-Xylene**	1,217,896 gal	3,176
Casein	3,519,873 lb	2,108
Inorganic bases, metallic oxides	199,007 lb	1,825
Potassium chloride or muriate of potash	13,346 tons	605
Chemical elements	na	507
Oils, distilled or essential	22,295 lb	134
Radioactive isotopes, chemical elements, and compounds nec[a]	110,310 millicuries	116
Uranium, thorium, and cerium compounds nec[a]	na	101
TOTAL IMPORTS VALUE		**$47,131**
U.S. TRADE SURPLUS		**$44,385**

[a] Not elsewhere classified. **na** = not available. **Source:** Commerce Department

strategically important technology but doesn't think much of Sutton's thesis.

"It's terribly hard to believe that," he says. "But I will go so far as to say that David Rockefeller will be skewed to what the Russians owe his Chase Manhattan Bank in commercial loans." Indeed, the Soviets do owe western financial institutions as much as $20 billion, according to the Federal Reserve. But those who follow Soviet credits assert that the U.S.S.R. needs connections to dollar credit too strongly to default on its debts.

It is the opinion of economist Joyce Kolko that both sides are in for deep trouble. Except militarily, the U.S.S.R. is not a strong country. And the West has just about dried up its ability to expand capitalism. The Third World is too deeply in debt, for one thing, she says, and markets in China and the Soviet Union are not going to pan out. She says they simply are too short of hard currency and outlines the severe problems coming in her book, "America and the Crisis of World Capitalism."

There is strong reason to believe, as Kolko suggests, that the real competition between the western and Soviet social systems will be staged in the Third World. Over the past several years, the U.S.S.R. has beefed up its naval forces. Indeed, as analyst Joseph Whelan says in an important Congressional Research Service study done for the House Committee on International Relations:

"Soviet activity has now extended beyond the Eurasian continent and the traditional 'national liberation zone' into Black Africa, suggesting the emergence of a new imperial phase in Russian history. Risks are apparent in the pursuit of this unmistakable imperialist policy that seeks to reconcile the requirements of détente in the West with the ideological imperative of revolutionary action in the Third World. Within this persisting, unresolved contradiction lie the seeds of potential . . . conflict."

But in his study Whelan documents a series of Soviet reversals in the Third World and doesn't think it will fare much better in its new adventures. In fact, Third World demands for a new international technological order are a downright embarrassment to the Soviet Union because the U.S.S.R. is lumped together with capitalist countries as technologically rich. Up to now, Brezhnev has not known how to respond to Third World demands for sharing technology.

So in a way two conditions exist in the Third World. One is the failure of Soviet Marxism to make much penetration and the other is the failure of western industrial capitalism to make an impact. Both are seen as enemies of Third World aspirations. To Third World leaders, both are part of the technological North. Thus, the Soviets and the Americans have, in a way, a common problem to solve.

There are attempts to build new definitions of reality here and there. One such builder is Howard Kurtz, who for the past 20 years has been intensely lobbying the Washington science and technology policy community for his concept of peace.

Kurtz almost escapes definition.

He is an aeronautical engineer by training and a theist by philosophy. Practically everyone in science policy circles in Washington knows him—from Congress' Office of Technology Assessment to the White House Office of Science & Technology Policy to the Advanced Research Projects Agency in the Pentagon.

The gist of his thought is this. The peace process today is really an arms process, bolstered by outmoded concepts of how wars are fought and, indeed, why the Soviet Union needs to expand. Kurtz says history shows that the Soviet Union always has tended to expand because it constantly feared encroachment by surrounding regions. The western military response to Soviet paranoia only increases that paranoia while lining the pockets of the arms industry.

He suggests another approach, taking maybe 10 to 20 years and involving the entire U.S. industrial and military establishment. The project would focus on world development through the techniques of military surveillance, sort of a latter-day interpretation of William James' 1910 essay, "The Moral Equivalent of War." This would give military techniques and efficiencies a nonwar outlet toward rebuilding society. He sees networks of satellites not only monitoring the world for hostile activity but, more important, for data on geology, geophysics, agriculture, natural resources, and environmental problems. If arms money went into economic and human development he believes the world would have its substitute for war.

William D. Carey, chief executive officer for the American Association for the Advancement of Science is another who insists on fresh thinking about the U.S., U.S.S.R., technology, and the Third World. Carey thinks along the conventional line that technological exports of any use to the Soviets should stop but that scientific exchanges should continue. But he does note a serious gap in thinking through the more "systemic" aspects of the competition between the two social and economic systems.

"I don't think we have any systematic answer," he says. "The whole trouble is that the more we get transfixed by the military escalation the more blurred our vision of the incendiary factors in the Third World becomes. There is no explicit process we come to in our policy management system here to properly calibrate the mix of U.S. interests in the Third World."

Carey believes the U.S. could have taken advantage of the Soviet move into Afghanistan to make some heavy propaganda points regarding its human rights policies in the Third World. "We could have shown the good cards we're playing in the Third World. But we can't even get this little Institute for Cooperative Technology through Congress. We don't argue for it in macro terms."

Another regret Carey has is the lack of global financial institutions' involvement in the evolution of a foreign policy that would deal with the new realities. Last August in an interview with C&EN, Jermen Gvishiani, deputy chairman of the Soviet State Committee for Science & Technology, emphasized that the U.S. and the U.S.S.R. face a "common enemy" that surmounts the political differences between the two systems. He didn't discuss how big a break the Soviet Union would have to make with its Russian-dominated past to make the dream of true cooperation come true. (Indeed, with the possible fall from favor of Gvishiani, such thoughts may be stilled for a time.) But his point was that the world was becoming too small, intertied, and dangerous for the two systems to dwell only on containment and competition. It wasn't the Brezhnev doctrine he was relating, but that the world could become such a dangerous place, by virtue of the imbalances now erupting, that the question would be one of common survival rather than the victory of one system over another. The enemy, he said, was disorder, chaos, or in the scientific analogy, entropy. This is where Soviet affairs consultant John J. Ford comes in with his views on reassessing the competition.

What the Soviets may have, Ford thinks, is a method of assessing instabilities within the capitalist system by virtue of their own techniques of "net assessment," or "correlation of forces." The military approaches to security, he says, may be totally out of phase with the dangers that jointly face capitalism and communism—which could well be overindustrialization, technology racing beyond the ability of Earth's resources to sustain the trend.

"Net assessment of the stability of East and West could be of the utmost importance to securing order in the 1980's," he tells C&EN. "U.S. strategic thought in the era of 'peaceful competition' might be focused on devising and implementing new governance processes rather than weapon responses in reply to new socialist weapons. Disruption of economic, energy distribution, international trade, social, and ecological networks

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could 'disorder' our system more efficiently and safely than would be possible with weapons of mass destruction."

These are areas where the U.S. and the Soviet Union could cooperate. And there are some efforts to begin such projects at the International Institute for Applied Systems Analysis near Vienna, Austria. The institute is jointly administered by the U.S. and U.S.S.R. It is the only research on which U.S. and Soviet scientists work side by side on common global problems.

For his part, Ford helped organize a special series of Defense Department meetings on the effectiveness of command, control, communication, and information systems in the defense network. Proceedings are not available, but the meetings attempted to inject wider-ranging thought into the meaning of security in a time of technological complexity.

What things appear to boil down to is this. U.S. technological strategy toward the Soviet Union is embodied in the Export Control Act. But that is not enough because administration of the act fails to take into account a strategy for conducting a genuine global competition with the Soviet system. Apparently, no such strategy exists. For that matter, regulations seldom differentiate between technological know-how and its product.

One would think, for example, that the soon-to-be-funded Institute for Scientific & Technical Cooperation in the State Department would embody some concept for applying technology to the Third World as a conscious response to the threat from Marxism. But those promoting ISTC say no such linkage should exist because the recipient countries would see themselves only a a ploy in the struggle between two superpowers, neither of which is particularly liked.

It is a dilemma, and in the end may bear on simple good will between peoples. To the Third World, both the U.S. and U.S.S.R. are technological superpowers. They play their war games while the rest of the world lies in want. Both powers face severe internal economic difficulties, yet both see the other side on the wane. Capitalism is seen as internally overextended with no place to grow; Soviet expansion is seen as ideologically tired, victim of traditional Russian paranoia, and, according to some analysts, under attack from Soviet intellectuals.

It would seem that the search for that "common enemy" is worth undertaking. It may have something to do with excess industrialization, excessive quest for power, perhaps even excessive quest for profit. □

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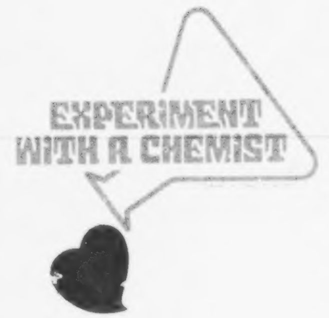

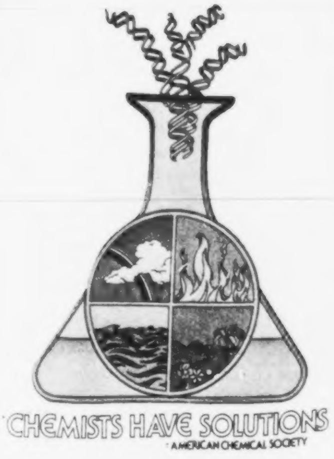

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Mineral-based inorganics in slow, profitable growth

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Genetic engineering: the concept becomes a diversified industry Page 15

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Cover: Sulfur being loaded into hopper cars. Photo courtesy of Texasgulf

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Mineral inorganics: steady and profitable

Sulfur and potash are doing best because of strong fertilizer market: lime is limited by slack steel market; phosphorus just survives

Many of the usual causes of excitement in commercial chemicals are denied the largest-volume U.S. inorganics based on minerals. Big product growth, high investment, and breakaway technology are not reasons to talk about lime, sulfur, potash, and phosphorus in comparison with petrochemicals or other groups.

These long-established products have a scale of their own which dictates a different kind of rating. From a huge production base, they sold reasonably well in 1979 on their own terms, a trend that has continued so far this year. They all have high plant capacity use.

In profitability, sulfur and potash are well off in tight markets because of a strong year in their dominant market, fertilizer. Lime is considered healthy, although its biggest market, steel, is soft because of the decline in U.S. automobile production. Lime's pollution-control markets are growing well.

The merchant stance of phosphorus is somewhat academic, since producers convert most of it to derivatives. Some of these have high investment rates, and the largest category, detergent phosphates, is making a comeback after a decade of decline. Overall, the phosphorus business is still static with economics under pressure from its energy-intensive cost structure.

Aside from phosphorus, the smallest-volume chemical of the four inorganics, the others are all big merchant commodities. Hence, they provide producers with a large revenue base and substantial profits for expansion or investment elsewhere. Combined production value of the four products will cross the $3 billion mark in another year or so. The $2.88 billion estimated value in 1980 is up 23% from $2.35 billion in 1979.

Over the past decade, the combined value of these inorganics has risen a little ahead of the general inflation rate. From $919 million in 1969, this value increased an average of 10% per year to $2.35 billion in 1979. The increase was largely related to increasing energy costs for sulfur, lime, and phosphorus, which require high temperatures in their production.

In tonnage produced, three of the four chemicals have little or no growth in sight this year, much as in the past decade. The fourth, sulfur, will have one of its best years with 7% production growth from all sources. Sulfur has had the best growth of the four in the past decade but has still averaged only 2% growth per year. Lime had zero average annual growth in the 1970's, potash output declined 2% annually, and phosphorus production fell 3% a year.

Even so, the size of these inorganics' production is imposing. At a combined 37 million tons (74 billion lb) in 1980, up 1 million tons from 1979, their volume is larger than that of the combined leading oil-based petrochemicals in C&EN's Key Chemicals series (C&EN, Nov. 19, 1979, page 10).

Market value is another matter. The four inorganics' merchant revenue in 1979 was probably only a third of the $4.5 billion from the leading petrochemicals. Hence, the inorganics, except phosphorus, are relatively cheap and invite large-scale use.

Despite their low price among major chemicals and the relatively high effect of transportation cost, sulfur and potash have a large foreign trade, with the U.S. a net importer in both cases. Foreign trade is quite small for lime and phosphorus.

Although considerable frustration is evident in these chemicals' production record in the 1970's, many producers are pushing new markets for them for the 1980's. To date, these markets are too new and too small to affect total volume in these materials.

Lime's hopes are largely in pollution control. In the late 1970's, lime had large increases in use in stack-gas scrubbers, sewage treatment, acid neutralization, and sulfur removal.

Phosphorus now has more than 10% of its use in specialty compounds going into flame retardants, lubricating additives, and pesticides. Combined growth of these could be about 5% a year. In addition, phosphorus finally may be out of the tunnel in detergent phosphates, its largest use, after a decade under pressure because of water pollution concerns. New formulations will increase phosphorus use in detergent phosphates slightly in 1980.

Sulfur and potash, despite growth in smaller uses, will depend on fertilizer for their fortunes, which is fine with producers, at least for now. Fertilizer was booming in 1979 and is expected to continue strong through 1980. However, fertilizer's history of big ups and downs lagging the general business cycle indicates that sulfur and potash will have more cycles in their future, despite optimistic predictions on worldwide fertilizer needs in the 1980's.

For details on the immediate 12-month market outlook for these four chemicals, see the following pages.

Bruce Greek, Houston, and
William Fallwell, New York

During 1970's, mineral-based inorganics grew little or declined in volume but doubled or tripled in value

	Production[a] (Billions of tons)			Production value ($ Millions)		
	1979	1969	Annual change, %	1979	1969	Annual change, %
Lime	20.4	20.2	0.1%	$350	$263	12%
Sulfur	11.7	9.5	2	800	360	8
Potash	2.3	2.8	−2	200	73	11
Phosphorus	0.46	0.62	−3	500	223	8

a Long tons for sulfur (1 long ton = 2240 lb). **Sources:** Commerce Department, Interior Department, industry and C&EN estimates

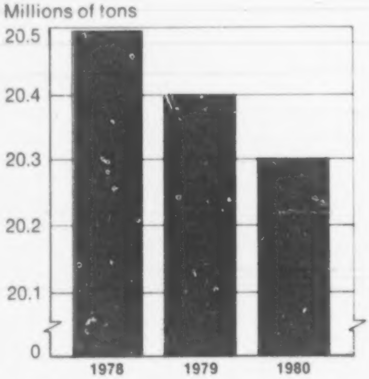
Key Chemicals

Lime

CaO

- ***Production easing***
- ***Capacity up a little***
- ***Prices rising***

PRODUCTION



Note: No capacity estimates are available.

HOW MADE

Calcining limestone (mainly $CaCO_3$*) to make quicklime, CaO, by driving off carbon dioxide; quicklime then hydrated with water to make hydrated lime,* $Ca(OH)_2$

MAJOR END USES

Metallurgy (mainly steel flux) 45%, chemical manufacture 10%, potable water treatment 10%, sewage and pollution control 5%

FOREIGN TRADE

Exports—about 50,000 tons in 1980, imports—rising to about 700,000 tons in 1980

PRICES

$35 to $50 per ton, depending on type

COMMERCIAL VALUE

$850 million for total production, 1979; $1 billion, 1980

U.S. lime producers face another sluggish year, similar to 1979. Production may decline slightly to 20.3 million tons from 20.4 million tons in 1979. Some new plants are being built, but a large part of this new capacity will replace obsolete capacity. Although exact capacity figures are hard to come by, capacity use probably is running 90% or better at present.

Prices for merchant lime and costs of captive lime will continue to rise as energy costs rise. Lime is energy-intensive because of the high temperatures used to calcine the ore.

Because nearly half of lime one way or another is used for metals and ore processing, lime's fortunes follow those of the metals industry, steel in particular. The steel industry, reflecting slow auto sales, has been having its own recession. Lime consumption as a result has fallen off and is now holding at a lower level than a year ago.

However, because steel also is tied to armament manufacture, some small improvement in steel demand could occur this year as government defense spending increases. Lime demand and production then could follow. If the reversal occurs soon enough and steel output rises enough during the second half of the year, lime production could pull off a small gain for 1980 instead of the forecast small decline

Even if lime production during 1980 equals or exceeds 1979 production, possibly rising to 20.5 million tons, it still will be below the record production high of 21.6 million tons established in 1974.

A major part of lime production goes for captive uses, mainly in steelmaking. However, this share of production has been in a decline accelerated by the slump in steel production. Currently, captive lime production accounts for less than a one-fourth share of total production.

Formerly, a large part of captive lime production was used to manufacture soda ash synthetically. With the shift to natural soda ash, many of the old lime kilns were shut down, further reducing the fraction of captive lime production.

Producers may phase out old kilns faster than they would otherwise because of stack emission regulations. Currently, the Environmental Protection Agency wants emissions limited to 0.3 lb per ton of feed limestone. At this limit, producers would be required to achieve about 99.9% collection, a goal not possible for some kilns without prohibitively expensive modifications. Some lime producers say that a limit of 0.6 lb per ton of feed may be more practical for new or modernized kilns. Implementation of emission standards has been delayed, so the effect on lime production during 1980 probably will be negligible.

A turnaround in lime production may be coming from demand for lime in stack gas scrubbing to reduce sulfur dioxide emissions from power plants. This use of lime increased substantially during 1979. However, this method of removing sulfur dioxide has technical problems as well as relatively high costs. Some industry sources predict a leveling off in use of lime in scrubbers later on in the 1980's.

Use of lime scrubbers is only one part of the substantial use of lime in various kinds of pollution control. In 1980, these uses, including sewage treatment, acid neutralization, and sulfur removal, could require more than 1.6 million tons, up from just over 1.2 million tons in 1978. Sewage treatment will take about 700,000 tons of the total. Sulfur dioxide removal probably will take 600,000 tons in 1980, possibly more.

Pulp and paper manufacture requires about 1 million tons a year of lime. This consumption is all in the initial charge to the mill. After this first loading, large quantities of lime are recovered in the chemical recovery section of pulp mills and re-used. This lime is not included in production estimates.

Most other uses of lime, such as construction of roads and parking lots, glass, and chemicals, are small and are not growing much on balance. Some of these applications of lime have shown declines in consumption in recent years.

On balance, lime production and consumption in 1980 will remain in a holding pattern. Producers will continue to be buffeted by high energy costs and new pollution control regulations. They will continue to pass costs along but probably will show little profit improvement.

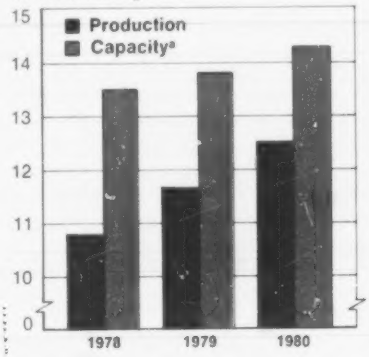
Key Chemicals

Sulfur

- ***Production rising***
- ***Demand strong***
- ***Prices rising***

PRODUCTION/CAPACITY

Millions of long tons



[a] First quarter; excludes standby capacity of about 5 million long tons at recovery plants and smelters.

HOW MADE

Melted from underground ores (Frasch); recovered from sulfur compounds processed in refineries, natural gas processing plants, and smelters

MAJOR END USES

Fertilizer manufacture 60%, chemicals manufacture 20%

FOREIGN TRADE

Exports—2.1 million long tons in 1980, imports—2.5 million long tons in 1980

PRICES

$116 per long ton, contract f.o.b. Tampa, with spot prices up to $30 higher; much lower prices for by-product at smelters

COMMERCIAL VALUE

$800 million for total production, 1979; $1 billion, 1980

U.S. sulfur producers are struggling to meet demand this spring, and the product is considered in short supply. Remaining inventories are being drawn down. Production is expected to increase this year 7% to 12.5 million long tons from 11.7 million long tons in 1979, but this rate is below what the market could take. Prices will continue to increase even after two increases posted so far this year.

As of now, producers' struggle to meet demand doesn't look as if it will become easier in 1980. However, a more severe recession than now is expected could change the market from tight to adequate with possibly some inventory rebuilding.

Sulfur capacity will expand at about the same rate as production this year. During 1979, capacity grew 4% from 13.8 million long tons in first-quarter 1979 to 14.3 million long tons in first-quarter 1980.

A breakdown of 1980 sulfur production forecasts shows Frasch sulfur still the largest source at about 6.75 million long tons. About 4.3 million long tons will be recovered from various oil- and gas-processing operations. Another 1.25 million long tons equivalent will come from metal-smelting operations. And about 300,000 long tons from pyrites.

About 60% of the 1980 production growth will be from Frasch production, which will increase about 500,000 long tons. Recovered sulfur production will be up about 300,000 long tons. Both smelter and pyrite sources for sulfur or its equivalent as sulfuric acid will hold about level with 1979 production.

Frasch sulfur production increases will result from fewer production problems at some locations and minor debottlenecking. As always, a severe hurricane at or near Frasch sulfur production locations on the Gulf Coast could depress production gains.

Production increases of recovered sulfur are well below forecasts of recent years. The reason for slower growth comes from a slower-than-expected shift to use of more sour crudes (those having higher sulfur content) by petroleum refiners. Even though the cost of sweeter crude oil is higher, refiners have expanded capacity to handle sour crudes only slowly, since they expect declines in gasoline demand to continue. Replacement of cutoff Iranian crude oils, relatively more sour than Arabian, also will tend to hold down recovered sulfur production.

Sulfur-equivalent production from smelters might fall significantly if there is a strike by smelter workers this year. However, overall smelter sulfur production could be about the same as in 1979 if any strike is short.

Sulfur production from pyrites is so small in the total picture that even large changes would have a tiny effect. No such changes are expected this year.

Since sulfur demand is now running ahead of supply, some spot prices are as much as $30 per ton above the $116-per-ton standard f.o.b. contract price at Tampa, Fla. At some locations, no spot sulfur is available at all.

The sulfur squeeze has been going for a year since cessation of Iranian oil and by-product sulfur exports in early 1979. A worldwide scramble for sulfur quickly dried up elemental and by-product supplies, even in the U.S. The tight market continued after Iranian oil exports resumed because of the worldwide boom in phosphate fertilizer. For 1980, a further supply constriction could develop if the copper industry suffers a strike when major union contracts expire at the end of June.

The demand strain comes almost entirely from demand for derivative sulfuric acid in making phosphoric acid for fertilizer materials. The outlook for fertilizer is quite uncertain because of political developments, most notably the phosphates trade cutoff with the Soviet Union. However, even if a slackening of robust U.S. demand occurs, exports probably still will take up the slack in non-Soviet areas.

Although demand remains strong for phosphate fertilizer materials, the quality of unmined phosphate rock is declining. The result is that more sulfuric acid is needed to make the same quantity of phosphoric acid. This can only add to the strain on sulfur supply.

None of the many nonfertilizer uses of sulfuric acid and elemental sulfur will fall off enough during 1980 to compensate for the pressure from fertilizer manufacturers. As a result, sulfur producers' race with demand may continue throughout the year.

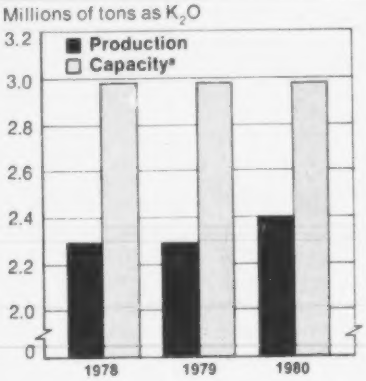
Key Chemicals

Potash

$KCl, K_2SO_4, K_2SO_4 \cdot 2MgSO_4$

- ***Output up slightly***
- ***Capacity flat***
- ***Prices firming***

PRODUCTION/CAPACITY



[a] First quarter

HOW MADE

Shaft mining of ore containing mostly chloride salt followed by purification of potassium chloride; solution mining of potassium salts, largely chloride, followed by purification

MAJOR END USES

Fertilizer 95%

FOREIGN TRADE

Exports—700,000 tons in 1980, imports—6.6 million tons in 1980, primarily from Canada

PRICES

$90 to $120 per ton, depending on grade and type

COMMERCIAL VALUE

$200 million for total production, 1979; $280 million, 1980

U.S. potash producers will be able to sell all they can mine this year as was the case in 1979. Potash production, however, will be just a third of U.S. demand, the rest of which will be met by imports, mostly from Canada.

U.S. potash production is expected to be almost 2.4 million tons measured as K_2O in 1980, up slightly from 1979 production of 2.3 million tons. To do this, producers will have to run their nameplate capacity of about 2.9 million tons of K_2O as high as it can go—something they also did in 1979.

Total use of potash in the U.S. in 1980 could top 7 million tons. More than 95% will be in fertilizer. The remainder, about 300,000 tons, will go to industrial uses, mainly manufacture of potassium chemicals for a variety of uses, including specialty glass, detergents, and drugs.

Foreign trade in potash is much higher relative to production or use than is trade in most other large-volume chemicals. Imports this year will total about 5.6 million tons measured as K_2O. Canada likely will account for all but 200,000 to 300,000 tons of the imports. Exports will come to about 700,000 tons or about 30% of U.S. production.

Geography accounts for much of this unusual import-export situation. When finally processed after initial mining, potash from just about all U.S. and Canadian sources meets standard specifications. This allows a lot of optimizing in shipping.

The result is that the U.S. has large exports to South America because economics favor these over Canadian material in some sales. By contrast, imports from Canada to U.S. consumers in upper-Midwest farming regions have lower freight costs than does U.S. potash brought from the Southwest.

For some years to come, Canada will remain the major supplier of potash to the U.S. In fact, Canada is expected to increase exports to the U.S. to handle most U.S. demand growth.

U.S. production may increase but not without problems. Ore quality in the principal potash-producing area in New Mexico is declining slowly in percentage of K_2O. This means that more raw material must be processed each year at higher energy costs just to sustain output.

About one eighth of U.S. potash capacity is based on solar evaporation to concentrate salts. Production from this capacity depends on the weather and so changes radically from year to year. However, it is not large enough to have a big impact on total U.S. production.

As might be expected for a product consumed almost entirely in a single end use, potash has developed several main grades. In practice, the name potash includes several potassium salts. The vast majority, about 95%, is potassium chloride, known in the trade as standard muriate of potash. The rest is potassium sulfate and a dual salt of potassium and magnesium sulfates. The sulfates are preferred for some crops such as tobacco and citrus because of the danger of "burning" with the chloride.

In granular fertilizer, potassium chloride is physically mixed with nitrogenous and phosphatic fertilizer materials. This use takes about 55% of muriate of potash. In fluid fertilizer, either solutions of up to 11% K_2O or suspensions of potassium chloride at higher concentrations are added to fluid forms of other fertilizer ingredients.

Industry sources expect that farmers will use all the potash available in the U.S. in 1980 in spite of some uncertainty about grain production. The likelihood of surplus potash this year seems remote. In fact, more potash might be used if it were available, since new research on crop production shows the value of added potash.

However, transportation limitations at seasonal peaks in demand hold down market growth. Storage capacity closer to the user continues to grow, but the current high cost of maintaining inventories works against greater product buildup before peak periods. One innovation being tried to alleviate the transportation problem is the use of unit trains to ship potash from Canada to the Midwest. The first of these, from CP Rail, went into operation in January with a goal of 250,000 tons per year.

For the potash industry in the U.S., 1980 now looks like an extension of recent trends. Growth in output will be small. No new capacity of any size will be added and existing capacity will be used to the hilt. Prices will increase to maintain profits as producers pass along increased costs of energy, other production factors, and transportation.

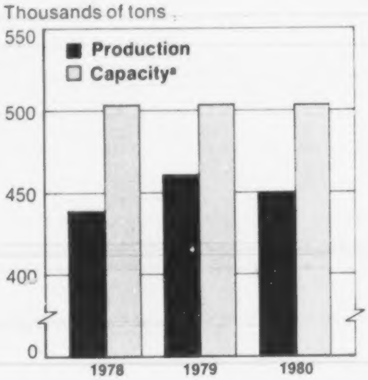
Key Chemicals

P

Phosphorus

- ***Output off a bit***
- ***Capacity flat***
- ***Prices rising***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Electric furnace reduction of phosphate rock with carbon and sand as aids

MAJOR DERIVATIVES

Phosphoric acid and derivatives 85%, other chemicals and derivatives 10%

MAJOR END USES

Detergents 45%, foods and beverages 15%, metal treating 10%

FOREIGN TRADE

Exports—down to about 25,000 tons in 1980 after surge in 1979, imports—negligible

PRICES

55 to 65 cents per lb

COMMERCIAL VALUE

$500 million for total production, 1979; $600 million, 1980

U.S. phosphorus producers were surprised by slightly larger demand than expected last year resulting from a surge in exports. However, producers expect production in 1980 to post a small decline. Forecasts put 1980 production at about 450,000 tons, off about 10,000 tons from 1979.

No increase in plant capacity, now about 505,000 tons, is expected for 1980. Prices probably will continue rising. However, market pricing in phosphorus is not very significant, since most phosphorus is converted to derivatives at the same site.

These output, capacity, and price conditions typify a very mature product. Production of phosphorus has tended downward in recent years mainly because of curbs or bans on derivative phosphates in detergent formulations. Capacity has been flat since 1976, when an electric furnace at Tennessee Valley Authority was shut down. No new capacity has been announced or even rumored.

A lack of capacity expansion when furnaces are running at 88% of nameplate capacity doesn't worry producers. In the past, capacity use has reached more than 95% on an annual basis. That can easily be done again if electric power is available at costs permitting additional output of phosphorus and derivatives and if customers are willing to pay.

Without a single ton of additional capacity, industry sources say that production of phosphorus could reach 480,000 tons per year, probably higher. In addition, one small unit, now closed, could be restarted, and debottlenecking might be possible on most other units as well.

Expansions in phosphorus demand could be coming in several smaller-volume uses such as sulfide, oxide, and chloride compounds. However, these uses together take only about 50,000 to 55,000 tons of phosphorus per year. If these uses grow at an optimistic rate of 5% per year—spurred by growing outlets such as flame-retardant additives for polymers, wear-extending additives for lubricating oil, and pesticides—their total effect on phosphorus demand still will be small.

By far the largest single use of phosphorus is still sodium, calcium, and potassium phosphates used in detergents as "builders" to minimize redeposition of dirt and to add other properties. These three phosphates account for more than one third of U.S. demand for phosphorus.

The decline in use of detergent phosphates since the mid-1960's led to the long decline in production of elemental phosphorus after the peak of 623,000 tons in 1969. However, few, if any, new curbs are due for detergent phosphates in specific U.S. regions. As a result, a slow renewed growth has begun for phosphate builders, roughly equal to population growth in U.S. market regions outside areas with curbs or bans. Sales of new powder detergent formulations with high phosphate concentrations are increasing fast, probably at the expense of liquid detergents, which could now have slower growth. The liquids were widely used as replacements for powders when phosphates came under the legislative gun.

For the longer term, the whole detergent picture is muddled. For 1980 specifically, current trends could bring a 1 to 2% increase in phosphorus use in detergent phosphate.

A distant second-largest use for phosphorus, about 15% of total demand, is in high-purity phosphoric acid and derivatives, called food grade, used in many prepared foods, beverages, and dentifrices. Again, many of these products have reached maturity with their slow growth tied to gross national product.

Crucial to most uses of phosphorus and derivatives is their cost compared to cost of potential substitutes such as detergent silicates. And crucial to phosphorus's own cost is the cost of energy, especially electric energy needed to run the furnaces that make it. Currently, energy costs are rising rapidly. Energy supply has some clouds over it, too, especially hydroelectric power at western U.S. phosphorus sites when rain and snowfall are abnormally low as in recent quarters.

It is certain that energy costs will increase the cost of phosphorus and its derivatives in 1980 and beyond. This will be a major factor extending phosphorus's defensive market posture of the past decade.

Chemical &
Engineering NEWS

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Chemical plant use continues to strain capacity Page 11

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News of the Week

- ***Coalition of labor, consumer groups*** *will hold "Big Business Day" to expose what it considers abuses by industry.* ***Page 4***
- ***Isocyanates capacity will be boosted*** *by new plants for BASF Wyandotte and Arco Chemical, expansions elsewhere.* ***Page 5***
- ***Celanese first-quarter earnings*** *were a record $36 million, a 13% increase over first-quarter 1979.* ***Page 5***
- ***Nuclear accident at Three Mile Island*** *will redirect efforts toward safety, House subcommittee reports.* ***Page 5***
- ***Kennecott Copper*** *gets into granular activated carbon market via Carborundum subsidiary plant in Oklahoma.* ***Page 6***
- ***Clot-dissolving enzyme urokinase*** *has been made in bacteria via recombinant DNA technique by Abbott scientists.* ***Page 6***

Business

- ***Chemical industry capacity use climbed*** *in second-half 1979 but it's doubtful that it can continue to rise.* ***Page 11***

International

- ***Mexico's synthetic rubber producers*** *aim to reduce the country's dependence on imports and dig into natural rubber's share of the elastomer market.* ***Page 13***
- ***Plan to protect Caribbean environment*** *from haphazard development of natural resources involves UN and Economic Commission for Latin America.* ***Page 15***

Government

- ***Budget cutting and energy bills*** *are tops on Congress' agenda.* ***Page 20***
- ***EPA's rules for testing chemicals*** *to meet health and safety requirements are still far in the future.* ***Page 22***

Science

- ***Further advances from the ACS meeting*** *include drug design that incorporates body reactions for activation, dinosaurs done in by asteroid, industrial uses of phase-transfer catalysis, support for Center for the History of Chemistry, and research on how an antitumor drug works.* ***Page 24***

Technology

- ***Laser spectroscopy technique*** *that counts atoms in a mixture, anilines' antiknock activity, ethylene glycol made from synthesis gas, optical fibers for long-distance analysis, carcinogen problems of synthetic fuels, and use of isotope ratios to pinpoint oil deposits revealed at meeting.* ***Page 29***

ACS Annual Report

1979 highlights: *ACS/CSJ congress in Hawaii, meeting of chemical society presidents in Washington, D.C.* ***Page 33***

ACS News

- ***Council acts on eight petitions*** *at national meeting in Houston.* ***Page 59***

Chemical capacity use up another notch

Despite signs of weakness in a number of products, overall capacity use at U.S. chemical plants rose to 81% by the end of last year

William F. Fallwell,
C&EN New York; Bruce
F. Greek, C&EN Houston

After holding level in the first half of 1979, capacity use at U.S. plants for basic chemicals swung up again in the second half.

By the end of the year, tight supply-demand for a dozen or so building-block products drove overall industry use of capacity to 81% of the nameplate (official) total and 88% of the effective maximum, C&EN finds in its latest semiannual survey.

However, as the industry averages moved up, a number of important products settled back. This suggests that overall capacity use cannot climb much higher.

In some cases, declines in capacity use were partly the result of new plants coming on stream—in ethylene and other basic olefins and aromatics, for example, as well as in vinyl acetate, carbon black, titanium dioxide, and 1,1,1-trichloroethane.

In many products, though, declines also may reflect softening markets. That could be true for propylene, for example, since polypropylene capacity use dropped noticeably by the end of 1979.

Benzene and *p*-xylene, too, may be tipping off slightly less robust business in their plant use declines. Excess production this winter in gasoline, a competitive outlet for these aromatics, may set the stage for further weakness.

In a separate measure of capacity use in leading polymers, C&EN finds overall averages little changed during 1979. Use of nameplate capacity stayed at 83%, slightly higher than in basic chemicals. Use of effective capacity edged up to a very respectable 90%.

In polymers, too, there were crosscurrents. Among the big thermoplastics, capacity use still moved up from the beginning of 1979 for low-density polyethylene, high-density polyethylene, and polystyrene. However, use stayed flat for polyvinyl chloride and sank for polypropylene.

Synthetic fibers show a similar pattern. Although capacity use rose by the end of 1979 in polypropylene (olefin) filament and acrylic staple, it declined considerably in hard-hit polyester filament and in nylon staple.

At the high end of the capacity use spectrum, seven basic chemicals and three polymers sport effective capacity use higher than 95%. That's up from only three basic chemicals at the start of 1979 and unchanged from three polymers.

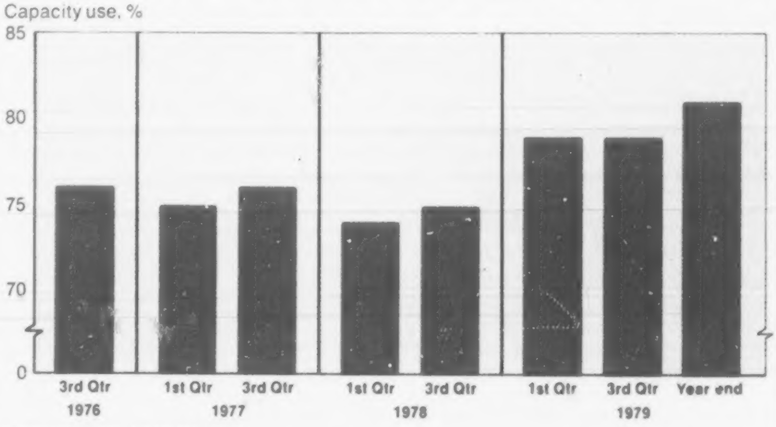
These ultrahigh figures touch some of the best chemical businesses—urea, methanol, soda ash, phosphoric

Polymers' nameplate capacity use stays high at 83%

	Year-end 1979			First-quarter 1979		
	Capacity	Capacity use		Capacity	Capacity use	
Billions of lb	(nameplate)	Nameplate	Effective	(nameplate)	Nameplate	Effective
Plastics						
Polyethylene, low-density	8.7	90%	97%	8.4	82%	88%
Polyvinyl chloride	7.5	79	92	7.0	79	92
Polyethylene, high-density	5.8	87	92	5.5	75	79
Polystyrene	5.3	83	92	5.2	71	[illegible]
Polypropylene	5.5	64	71	4.8	73	[illegible]
Synthetic fibers						
Filament yarn						
Polyester	2.1	73	78	2.1	86	91
Nylon	2.0	88	94	2.0	90	96
Olefin	0.92	73	78	0.92	72	77
Staple						
Polyester	2.7	92	98	2.6	93	99
Nylon	1.0	88	94	1.0	98	104
Acrylic	0.84	93	99	0.87	89	95
AVERAGE		83%	90%		83%	89%

Sources: Industry sources, Textile Economics Bureau, Society of the Plastics Industry, C&EN estimates

Nameplate capacity use is up from mid-1970's doldrums



Sources: Industry, C&EN estimates

Effective capacity use reaches 88%

Billions of lb per year unless otherwise noted[a]	Year-end 1979 Capacity (nameplate)	Year-end 1979 Capacity use Nameplate	Year-end 1979 Capacity use Effective	First-quarter 1979 Capacity (nameplate)	First-quarter 1979 Capacity use Nameplate	First-quarter 1979 Capacity use Effective
Oil-based petrochemicals						
Ethylene	38.5	82%	91%	35.2	85%	95%
Propylene (chemical)	22.5	61	68	20.0	72	80
Butadiene[b]	4.7	77	86	4.3	78	87
Benzene (bg)	2.6	66	72	2.3	70	76
***p*-Xylene**	5.3	75	83	4.3	84	92
Natural gas-based petrochemicals						
Ammonia (mt)	24.0	89	94	20.4	74	78
Urea (mt)	7.7	86	96	7.5	80	89
Methanol (bg)	1.35	97	108	1.35	78	87
Formaldehyde (37% solution)	8.5	75	79	8.5	78	82
Chlor-alkalies						
Chlorine (mt)	14.4	90	95	14.3	83	87
Caustic soda (mt)	15.5	90	95	15.2	76	80
Soda ash (mt)	9.7	93	98	9.7	82	86
Acids						
Sulfuric (mt)	57.5	83	87	56.0	75	79
Phosphoric (P_2O_5, mt)	11.0	100	105	10.7	95	100
Industrial gases						
Oxygen **Nitrogen** } (total, liquid, ttd)	32.4	68	86	30.7	67	86
Carbon dioxide (ttd)	14.1	69	79	12.5	65	77
Mineral-based inorganics						
Sulfur (mlt)	14.3	79	—	13.8	72	—
Potash (mt)	2.9	83	—	2.9	79	—
Phosphorus (tt)	550	90	95	550	83	87
Plastics monomers						
Styrene	9.3	94	99	8.2	88	93
Vinyl chloride	8.7	83	92	8.5	90	99
Propylene oxide	3.0	80	89	3.0	85	94
Fiber monomers						
DMT/PTA[c]	7.3	77	86	7.3	68	77
Ethylene oxide	6.6	90	100	5.8	79	88
Cyclohexane	3.2	75	79	3.2	76	80
Adhesives and coatings monomers						
Phenol	3.5	86	96	3.5	80	88
Vinyl acetate	2.5	80	84	2.2	82	86
Pigments						
Carbon black	4.3	74	82	4.0	91	99
Titanium dioxide (mt)	1.04	70	78	0.885	82	91
Solvents						
Ethanol (mg)	270	79	83	270	72	76
1,1,1-Trichloroethane	1.3	57	63	0.99	71	79
AVERAGE		**81%**	**88%**		**79%**	**86%**

a bg = billions of gal, mt = millions of tons, tt = thousands of tons, ttd = thousands of tons per day, mlt = millions of long tons, mg = millions of gal. **b** Based on extraction capacity of steam-cracking plants and dehydrogenation capacity only of dehydrogenation producers; could be more if extraction capacity of dehydrogenation plants were included. **c** Dimethyl terephthalate plus purified terephthalic acid, not including acid converted to DMT. **Sources:** Industry and government sources, C&EN estimates

C&EN's capacity use indicator—the ground rules

Capacity use at chemical plants is difficult to measure and requires certain assumptions to bring some order to the maze of variables affecting this critical indicator of the industry's health.

With the help of industry and government sources, C&EN measures capacity use as a percentage of both nameplate and effective maximums. Nameplate capacity is the official design capacity of plants at nonstop use all year. Effective capacity is the practical maximum capacity after reductions for regular maintenance shutdowns and changes in product mix. Effective capacity runs from 85 to 95% of nameplate for most chemicals.

Capacity use is given semiannually over a calendar quarter with no seasonal adjustment. The figures include plants actually running. Figures exclude new plants just starting up and old plants knocked out for long periods by accidents or mothballing. As much as possible, capacity figures stay current with expansions and debottlenecking.

Capacity figures do not take into account temporary fluctuations for fuel and electric power interruptions, equipment failure, and feedstock scarcity or substitution. The feedstock variables have been especially important in 1979, further reducing maximum output for a number of important products.

Products in C&EN's capacity use survey are the same as those in the Key Chemicals and Key Polymers series. Those are the core products of the industry, the basis for downstream production of thousands of more specialized products.

acid, styrene, ethylene oxide, low-density polyethylene, and polyester staple. In some of these products, high capacity use has flushed out a lot of new investment—methanol, soda ash, ethylene oxide, and low-density polyethylene. In the rest, producers are still cautious after generally overexpanding in the mid-1970's.

Capacity use in some other chemicals is tighter than shown by the arithmetic. One reason is feedstock scarcity or substitution. Unusual feedstock factors were important in 1979—though less so by the end of the year—for propylene, benzene, ammonia, urea, and carbon dioxide.

Propylene and benzene output for chemical use was held back by oil refiners' drive to divert some feedstock streams into gasoline. Ammonia, urea, and carbon dioxide were curbed for a while by lack of economical supplies of natural gas.

In ammonia and urea, feedstock factors resulted in considerable shutdown of capacity during much of 1979. But by year's end, data strongly suggest that a lot of sidelined capacity came back on stream. For this reason, C&EN now lists full ammonia capacity of about 24 million tons, even though some of this total is undoubtedly still out of operation.

Feedstock substitution also cut into 1979 production of ethylene coproducts, including propylene, benzene, and butadiene, from heavy liquids-based crackers. Feedstock factors may be less important in 1980 if market weakness spreads in a recession. A forerunner could be butadiene, whose problems in the rubber market outweigh production limitations from feedstock substitution. As a result, it is likely that butadiene plant capacity is less than the 4.7 billion lb listed by C&EN, since some older plants are probably being shut down. □

Mexican rubber industry plans big growth

Producers set goals to reduce imports of synthetics and cut natural's share of market; they need to raise capacity, diversify into other rubbers

Earl V. Anderson
C&EN, New York

Mexico's synthetic rubber producers have set two major objectives for themselves. One, like most other segments of Mexico's chemical industry, is to reduce the country's dependence on imported elastomers. The other is to lower natural rubber's share of the total Mexican elastomer market.

If projections bandied about by the Mexican rubber community prove to be accurate, the country's synthetic rubber companies figure to make advances toward both goals. But it will be a gradual process.

With the exception of 1974, when synthetic elastomer imports surged to 31%, imports have accounted for 15 to 21% of the Mexican synthetic rubber market. For the past two years, imports have hovered around 20% of synthetic rubber consumption. This year, imports may be shaved to around 17 to 18%.

The big problem facing Mexico's synthetic rubber industry is that it produces only three types of synthetic elastomers—styrene-butadiene rubber (SBR), polybutadiene, and nitrile.

The industry produces no butyl rubber, no polyisoprene, no ethylene-propylene polymers, and no neoprene. These elastomers, along with a scattering of other specialty products, account for 75% or more of Mexico's total imports of synthetics. And until one of Mexico's synthetic rubber producers adds some of these elastomers to its product line, Mexico still will be more dependent on synthetic imports than it wants to be.

By 1987, for instance, when Mexico's total synthetic rubber demand is projected to reach 243,000 metric tons—more than double what it will be this year—demand for synthetics that the country doesn't produce today is projected to reach 33,300 tons. Even if Mexico completely eliminates imports of synthetic elastomers that it already produces, those that it still doesn't produce will account for almost 14% of the country's demand in 1987.

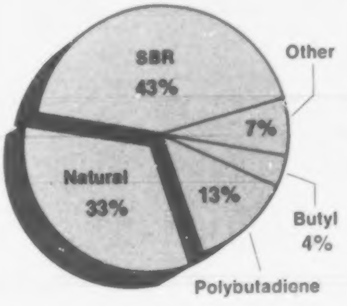
For a country that is bursting at the seams with hydrocarbon raw materials, such heavy dependence on imported synthetic elastomers may be unacceptable seven years down the road. Right now, however, there are no specific projects for butyl, polyisoprene, ethylene-propylene elastomers, or nitrile rubber on producers' drawing boards. And only one company admits—vaguely—that it is considering production of one or more of these elastomers.

Mexico's synthetic rubber producers are, however, taking steps to meet the country's growing appetite for elastomers that they already produce. Hules Mexicanos S.A. plans to increase its SBR capacity 77% over the next three or four years. The company, which is 60% owned by Mexico's national oil company, Petroleos Mexicanos, and 40% owned by Canada's Polysar, operates a 52,000 metric-ton-per-year SBR plant at Tampico. But Hules Mexicanos will be adding a 10,000 metric-ton-per-year line there that is expected on stream by this July. Another 10,000-metric-ton expansion will be ready by the first quarter of 1981. And Hules Mexicanos says that it will be putting in an additional 20,000 metric tons of SBR capacity by 1983 or 1984.

Negromex S.A., Mexico's other major synthetic rubber producer, also is on an expansion binge. It has a 45,000 metric-ton-per-year solution polymerization plant that can produce either SBR or polybutadiene at Salamanca. A company spokesman says that, right now, the plant is geared to produce 18,000 metric tons of SBR and 27,000 metric tons of polybutadiene.

Negromex, of which Phillips owns 40% and the remainder is owned by Mexican interests, is adding 10,000 metric tons of capacity at Salamanca. The addition is scheduled to be on stream during the second half of 1981.

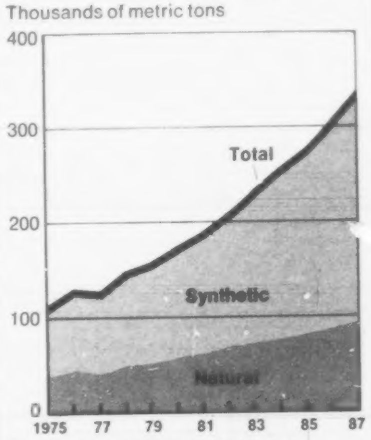
Natural rubber makes up a third of Mexico's rubber use



If these expansions come on stream as planned, Mexico's SBR capacity will increase 71%—from 70,000 metric tons to 120,000 metric tons. This assumes, of course, that Negromex splits its new capacity at Salamanca between SBR and polybutadiene as it does now with its existing capacity. Using the same assumption, the country's polybutadiene capacity will jump 56%, from 27,000 metric tons currently to 42,000 metric tons by late next year.

With these expansions, Hules Mexicanos and Negromex likely can handle Mexico's SBR requirements through 1985, when demand is ex-

Mexican rubber use to rise sharply during 1980's



Sources: Asociación Nacional de la Industria Química, industry data

Natural rubber use will lose ground to synthetics in Mexico

Thousands of metric tons	1979	1980	1981	1982	1983	1984	1985	1986	1987
ELASTOMERS NOW PRODUCED IN MEXICO									
SBR	62.4	68.4	75.2	82.0	91.6	100.1	110.1	121.6	134.2
SBR latex	5.6	6.2	7.0	7.7	8.4	9.5	10.6	11.8	13.2
Polybutadiene	19.2	22.0	25.6	29.6	33.7	39.2	45.0	51.4	58.8
Nitrile	1.2	1.4	1.6	1.8	2.0	2.3	2.8	3.1	3.5
Total	**88.4**	**98.0**	**109.4**	**121.1**	**135.7**	**151.1**	**168.5**	**187.9**	**209.7**
ELASTOMERS NOT NOW PRODUCED IN MEXICO (IMPORTS)									
Butyl	6.6	7.1	7.7	8.5	9.2	10.4	11.0	11.9	13.1
Polyisoprene	1.8	2.0	2.2	2.3	2.5	2.8	3.0	3.3	3.6
Ethylene-propylene	1.6	1.9	2.2	2.4	2.8	3.3	3.8	4.7	5.4
Neoprene	3.7	4.2	4.5	5.0	5.5	6.2	6.7	7.3	8.0
Other	3.3	3.8	4.0	4.7	4.3	4.2	4.0	3.9	3.2
Total	**17.0**	**19.0**	**20.6**	**22.9**	**24.3**	**26.9**	**28.5**	**31.1**	**33.3**
Total synthetic rubber use	**105.4**	**117.0**	**130.0**	**144.0**	**160.0**	**178.0**	**197.0**	**219.0**	**243.0**
Natural rubber use[a]	49.6	55.0	59.0	65.0	70.0	75.0	81.0	86.0	92.0
Total rubber use	**155.0**	**172.0**	**189.0**	**209.0**	**230.0**	**253.0**	**278.0**	**305.0**	**335.0**
% Natural of total	32.3%	32.0%	31.2%	31.1%	30.4%	29.6%	29.1%	28.2%	27.5%

a Including latex. **Source:** industry sources

pected to reach 110,000 metric tons. By then, the country's two SBR producers undoubtedly will be considering even more SBR capacity.

Mexican SBR consumption, which grew at about 8% per year throughout the seventies, is expected to increase at or near that rate for at least the next seven years. If it does, demand in 1987 will reach 132,000 metric tons. And more capacity obviously will be needed if Mexico doesn't want to revert back to imports.

Mexican imports of SBR have fluctuated between a high of 9266 metric tons and a low of 789 metric tons since 1974. This year, SBR imports probably will decline as a result of the new capacity that Hules Mexicanos soon will start up. After next year, imported SBR will all but disappear in Mexico, with the exception of some specialty grades.

Negromex, if not some future new producer, will have to add more polybutadiene capacity even before 1985. Negromex's 42,000 metric tons of polybutadiene capacity will enable it to meet Mexican demand through 1984. Consumption that year probably will hit 39,200 metric tons, up 78% over the 22,000 metric tons that Mexico will need this year. In 1985, estimated consumption of 45,000 metric tons will exceed Negromex' capacity.

Despite ample capacity in Mexico, imports of polybutadiene amounted to 9.1% of demand in 1978 and an estimated 5.2% last year. This year, however, imports' share of the Mexican polybutadiene market are expected to drop to about 3.6%.

In addition to SBR and polybutadiene, Mexico also produces nitrile rubber and SBR latex. Hules Mexicanos is the country's sole nitrile producer, with a capacity at Tampico of 1500 metric tons annually. The company has no expansion plans in the works, even though Mexican nitrile demand has been estimated to be 1400 metric tons this year and 1600 metric tons next year. Nitrile imports have been relatively small, amounting to only a few per cent of Mexican demand. But if new nitrile capacity isn't started soon, imports will have to increase to meet demand.

Mexico's nitrile consumption is projected to grow at an average 12% annual rate over the next seven years, which will make nitrile one of Mexico's fastest-growing elastomers. Only polybutadiene and ethylene-propylene polymers will sport faster growth rates in the eighties.

Mexico's SBR latex capacity will start being squeezed by 1983. Two companies—Hules Mexicanos and Industrias Resistol S.A.—have a combined SBR latex capacity of about 8500 metric tons. Industrias Resistol, wholly owned by Mexican investors, operates a plant at Lerma, near Mexico City.

Demand for SBR latex in Mexico grew at an average annual rate of 12.8% during the 1970's. And even though this growth rate will ease off to about 11% annually in the eighties, consumption likely will increase from 6200 metric tons this year to 13,200 metric tons in 1987.

All in all, a 66% increase in synthetic rubber capacity in three or four years is no small accomplishment. But clearly, Mexico's synthetic rubber industry will have to develop more ambitious plans if it is to keep pace with internal demand, decrease imports, and, as it also hopes, increase exports.

The styrene and polybutadiene expansions already under way or planned will help for a few years. But more still will be needed for these two elastomers, for nitrile and SBR latex, and for the other major elastomers that Mexico has yet to tackle. An official of one Mexican synthetic rubber producer speaks of eventually exporting surplus material, especially to other Latin American countries. It is true that Mexico already does export some synthetic elastomers but volumes are small—only 1800 metric tons in 1978, 2100 metric tons last year, and an estimated 2500 metric tons this year. Of these exports, 70 to 80% is SBR.

What is painfully apparent is that Mexico will have no surplus elastomers to export unless it adds new capacity. There seems little doubt that it will come, though it may take a few years.

When and if Mexico's synthetic rubber producers do add new capacity, they will have no problems with raw materials. Pemex has several ambitious petrochemical expansion projects under way or planned that include feedstock for synthetic rubber. Butadiene capacity, for instance, will be expanded from 55,000 metric tons to 155,000 metric tons. Styrene capacity will jump from 33,000 metric tons to 183,000 metric tons. And Pemex plans to add 100,000 metric tons to the 74,000 of acrylonitrile capacity it already has. ☐

1979

American
Chemical
Society

ANNUAL REPORT

William J. Bailey

BOARD CHAIRMAN'S MESSAGE

The national charter of the American Chemical Society, which was enacted by Congress and signed by Franklin D. Roosevelt in 1937, sets three main goals for the society—"fostering public welfare and education, aiding the development of our country's industries, and adding to the material prosperity and happiness of our people." In 1979, for the first time, the society adopted a restatement of its long-term goals and set specific 1980 objectives toward accomplishing those goals.

Major functions of ACS fall under four main headings: Promote the extension and transmission of chemical knowledge; foster the use of chemical knowledge to advance the public welfare; enhance the education, productivity, and professional well-being of the individual chemist or chemical engineer; and strengthen the vitality of chemical institutions. Under these main headings, 13 subheadings and 31 specific objectives for 1980 were selected, a complete list of which was published in C&EN, Feb. 11, 1980, page 36. ACS always has been outstanding in the fields of exchange of scientific information and chemical education, but adoption of these new statements of our goals commits us to a better balance of our traditional activities with those in member and professional relations, public affairs, and public relations.

In the field of public affairs for 1979 the highlights include publication of the second edition of "Cleaning Our Environment—a Chemical Viewpoint," and establishment of an information referral service at ACS headquarters in the field of chemical health and safety. ACS issued a record number of public policy statements, 19, during the year. To implement one of the statements, "Industrial Innovations and Private Investment in R&D," a Task Force on Industrial/Academic Cooperation was established under the chairmanship of Norman Hackerman.

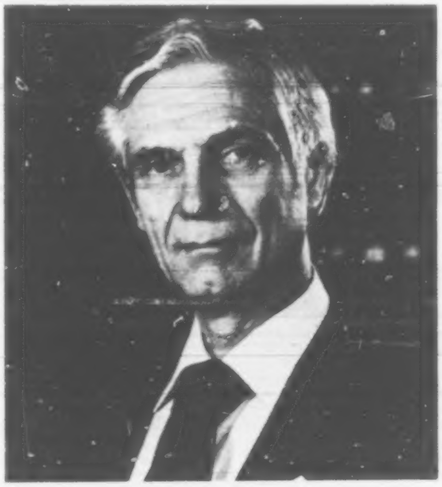
In the academic arena we launched our new publication, *SciQuest*, which is targeted for high school science students. We also published the third edition of "Safety in Academic Chemistry Laboratories." ACS approved a program whereby small colleges can purchase *Chemical Abstracts* with discounts up to $4500 and also receive free a number of *CA* services. *CA Selects* was expanded and has become a major product of ACS. Production rate of ACS Video Courses in Continuing Education was doubled, and a comprehensive offering of courses is now possible.

In the field of member services, we initiated group flights to national ACS meetings; we predicted that at least 500 members would utilize the service to the Houston meeting and at least 1000 would take advantage of the reduced fares to San Francisco. Since the savings average more than $150 per passenger, the total savings for members will be substantial. In addition, we hope to generate at least 40 free tickets that will be made available to local sections that help arrange the group flights. Cards entitling member discounts of up to 30% on car rentals for either personal or business purposes were sent to all members. Since ACS life insurance is one of the best bargains in the insurance field, often saving members several times their annual dues, the board approved offering one-year free life insurance to all new members as a recruitment incentive for an indefinite extended period. A search for other low-cost services to members is under way.

The board met with officers of the American Institute of Chemical Engineers in September to exchange views and explore possible areas of cooperation. The initial discussions were very fruitful and a number of joint projects are now under way.

In the international chemical area, 1979 was a banner year. It began with the joint meeting in Hawaii with the Chemical Society of Japan, in cooperation with the Chemical Institute of Canada, the Royal Chemical Institute of New Zealand, and the Royal Chemical Institute of Australia. It also included the 7th International Meeting of Chemical Society Presidents in Washington, D.C. The Agency for International Development funded two cooperative research projects that were recommended by a workshop in Egypt and a second workshop for 1980 in India was funded by the National Science Foundation.

WILLIAM J. BAILEY



Gardner W. Stacy

PRESIDENT'S MESSAGE

During my term as ACS president, I was involved in more than 50 different events. I lectured before or participated in local section meetings, regional meetings, divisional meetings, local section officers' conferences, and award banquets, or I presided over various meetings of the society. I had the privilege of addressing some very interesting non-ACS gatherings at various locations, which included the Engineering & Science Foundation of Dayton; a joint Phi Beta Kappa-Sigma Xi initiation luncheon at the University of Missouri, Columbia; the Dallas Society of Analytical Chemists, Air Products & Chemicals Inc., Allentown, Pa.; the Technical Community, Monsanto, St. Louis; and the R&D staff at Mobay Chemical Co. at both New Martinsville, W.Va., and at Pittsburgh.

Because of conflicts during my presidential term, I was unable to accept all the invitations to speak that were extended. However, some of these are being carried over to my 1980 term as immediate past-president.

Aside from communication with ACS members, my main attention was focused on the worldwide energy problem, more effective ACS service to industrial chemists, and international meetings. With the help of W. M. Tuddenham's subcommittee from the Committee on Membership Affairs, I staged the first Presidential Conference for Industrial Chemists in St. Louis. A major recommendation of that conference is that ACS seek out innovative and effective methods to communicate various ACS services and programs to its members. It is clear that ACS already has available much that members want, but that they do not realize exists. We should improve upon this situation as rapidly as possible. The full report including recommendations of the conference is now being prepared and will soon be available.

It is my hope that the Conference for Industrial Chemists will become a permanent forum for this sector of the society's membership, and indeed, one of the conference's recommendations is to continue scheduling conferences on a regular basis.

Aside from speaking widely on the energy challenge, I also selected this theme for the Second ACS Presidential Plenary Program, scheduled at the 178th ACS National Meeting in Washington, D.C. Melvin Calvin and John Deutsch were featured in this program on energy policy and research and attracted an audience of well over a thousand. The reception which followed, sponsored by the Chemical Society of Washington at the Corcoran Gallery of Art, also was an outstanding attraction.

International meetings were in the spotlight for ACS during 1979. ACS joined with the Chemical Society of Japan and the chemical societies of Australia, Canada, and New Zealand in Honolulu to produce a record program of papers. I felt fortunate to copreside with Yasuhide Yakawa, president of CSJ, over a unique joint Award Banquet with ACS. Another major event was a luncheon for a visiting delegation of chemists from the People's Republic of China.

Later in the year, following the Washington meeting; I was again very fortunate to be involved in a special international event, the 7th International Meeting of Chemical Society Presidents, as this event returned to the site of its inaugural meeting originated by former ACS president Charles G. Overberger. The topics that were discussed were: aid to developing countries, the role of chemistry and of chemical societies in the transfer of science and technology among nations, programs for the international exchange of chemists, formation of an international chemical society, chemical cooperation in establishing regional research centers in developing countries, upgrading chemical education and the practice of chemistry in developing countries, developments in the registration and licensing of chemists, relationships between universities and chemical industry, and chemistry's role in the provision of energy.

GARDNER W. STACY

FROM THE EXECUTIVE DIRECTOR

Raymond P. Mariella

Achievement of an all-time high in membership, initiation of book sales to the People's Republic of China, and increasing emphasis on government relations were among the outstanding developments of 1979 for ACS.

The year-end member total of 118,214 was 1751 above the previous record, set in 1969. With resignations running below average, prospects for continuing growth in 1980 seemed excellent.

For me personally, the year's highlight unquestionably was my visit to the People's Republic of China last spring with a group of scientific and educational publishers. Subsequently, ACS received a substantial book order and a smaller order for ACS Audio Courses. We anticipate increased sales of books, journals, and other products to the Chinese.

On a second journey abroad, I visited Achema in Frankfurt last June and garnered several ideas for our own expositions. While there I conferred with James V. Seals, manager of international marketing for Chemical Abstracts Service, and leaders of numerous European scientific organizations.

ACS received a National Science Foundation grant to cosponsor with the Indian Chemical Society a 1980 workshop in India to prepare a list of projects on which scientists of both countries might collaborate. Meanwhile, the Agency for International Development funded two projects recommended at a similar workshop in Egypt in 1977.

The society has continued to make available to Congress and to federal agencies the expertise of its members, submitting a record 19 public policy communications to appropriate officials during 1979.

ACS gave the National Research Council $25,000 to help support a study of effective laboratory procedures for the safe handling and disposal of hazardous substances. We in turn received a $30,000 grant from the National Science Foundation to support a "Physically Handicapped in Science" project.

The society started cooperating with the National Cancer Institute in a study of the mortality experience of society members. We also continued to work with the Council on Postsecondary Accreditation (COPA) to develop new guidelines and criteria for evaluating accrediting groups. If accepted, the ACS system, which is simpler and less costly than COPA's, may be offered as a model for other discipline-oriented agencies.

Among other 1979 highlights were: the first meeting (at the ACS building in July) of all society segments concerned with marketing; appointment of a new auditing firm, Coopers & Lybrand, which offers a wider range of services than was previously available; and completion of arrangements for a car rental discount for all ACS members and for group plane fares to the Houston and San Francisco national meetings.

As with government officials, I have tried to establish and maintain good relations with chemical industry representatives, through the Chemical Manufacturers Association, and with leaders of other professional societies, through the Council of Engineering & Scientific Society Executives (in July I was elected to a three-year term on the CESSE board of directors). I also have continued my interest in academe. In October, I lectured on "Life as a Chemical Professional" at three Texas universities under the auspices of the Robert A. Welch Foundation. I stressed the many valuable services offered by ACS.

My saddest duty of the year was attendance at funeral services in the MIT Chapel for Henry Hill. At his son's request, I spoke briefly on Hill's many contributions to our science, our profession, and our society—which he served so well as president in 1977.

RAYMOND P. MARIELLA

MEMBERSHIP AFFAIRS

NEW MEMBERS

An all-time high in total ACS membership was recorded in 1979, surpassing the record set a decade earlier by some 1400. The total at the end of 1979 was 118,214, compared to 116,816 in 1969, the last year of $16 annual dues. Membership in 1978 was 116,240. Of the 8070 new members admitted in 1979, 38% were students, with full-dues members accounting for the balance. The Admissions Committee, appointed by the president from members of Washington, D.C., area sections, considered 9773 applications during the year (1097 were accepted for 1980 membership).

Emeritus status was granted 1324 retired members with at least 35 years of membership, bringing the total in this category to 6904 at year's end. Of these, 273 were recognized for having reached their 50th year as members. In addition, retired members paying dues at half the regular rate totaled 3115, bringing the grand total of retired to 10,019, or 8.5% of all ACS members.

The Admissions Committee also approved the advancement of 289 associate members to full membership and the enrollment of 71 national affiliates. Resignations effective Jan. 1, 1980, totaled 1392, down 235 from the previous year, and 4230 were dropped for nonpayment of dues, 72 fewer than in 1978.

Membership statistics

	Dec. 31 1978	1979
Paid members and associate members		
No discount	92,826	93,934
Student discount	9,354	9,727
National service discount	7	9
15-year retired discount	3,537	3,115
Life members	2	2
Dues deferred—unemployment	342	312
Disabled	83	97
Emeritus status members	5,824	6,904
Total members in good standing	**111,975**	**114,100**
Unpaid members	4,265	4,114
TOTAL MEMBERSHIP	**116,240**	**118,214**

Membership admission data	Dec. 31 1978	1979	Membership retention Year	Per cent
Full rate	4978	5033	1972	94.1%
Student discount rate	2720	3037	1973	94.1
National service rate	—	—	1974	94.3
15-year retired rate	8	—	1975	95.1
	7706	**8070**	1976	94.8
			1977	94.7
New student members as %			1978	94.9
of total	**35.3%**	**37.6%**	1979	95.2

Jan. 1, 1979			**110,311**
Dec. 31, 1979			**118,214**
Less:			
Resignations effective 1/1/80	(1627 last year)	1392	
Dropped effective 1/1/80	(4302 last year)	4230	
Total removed from rolls	**(5929 last year)**	**5622**	**(5,622)**
Net membership carry-over from 1979			112,592
Plus: New members effective Jan. 1, 1980			1,097
Jan. 1, 1980			**113,689**

EDUCATION

High school chemistry. In January 1979 the ACS Office of High School Chemistry was established to provide programs and services for high school chemistry teachers. During its first year the office produced two publications, "American Chemical Society Awards to High School Teachers" and "Programs for High Schools—A Local Section Activity Book." The office sponsored its first Expert Demonstrator Training Activity (EDTA) at the University of Wisconsin, Madison, for representatives from 12 local sections who will in turn conduct demonstration workshops for high school teachers in their communities. Following the donation of 34 films by Imperial Chemical Industries Americas, the office established a high school film library for free use by ACS teacher members.

Project SEED. As in past years, the Catalyst program continued to dominate Project SEED activities, with more than 127 disadvantaged high school students participating in summer research programs at 58 colleges through ACS funding. An additional 35 students were able to participate through contributions from local sources, including ACS local sections, chemical companies awarding grants to specific colleges, Neighborhood Youth Corps, and chemistry departments. Another facet of Project SEED enabled about $250,000 worth of journals and reference materials to be placed in colleges and universities serving the disadvantaged.

Student affiliates. Ten new student affiliate chapters were chartered in 1979, bringing the total to 729. Seventy-five hundred student affiliates were enrolled; of this number, 39% were women, an increase of 9% since 1974. Nineteen chapters received grants of $50 to $250 for innovative chapter projects; each chapter must match the amount of its grant through its own fund-raising efforts. The Student Affiliate Newsletter increased from 12 to 16 pages and from three issues to four per year. Program aids produced and sent to faculty advisers included a directory of speakers and tours, a catalog of films available to chapters through the Student Affiliate Film Library, and a cross-referenced listing of chapters and local sections. Ten thousand T-shirts and 20,000 bumper stickers were sold during the year.

Cooperative education. July 1979 marked the establishment and staffing of the ACS Cooperative Education Service to promote the use of practical, chemistry-related work experience as a complement to classroom learning and to coordinate ACS activities in this area. In addition to its direct educational benefits, cooperative education helps students make informed career choices, is a useful and inexpensive recruiting tool for employers, and increases the interaction between the academic and industrial components of the society. The service is unique in that it is designed to reach an entire profession—students and representatives of chemical employers and educational institutions—rather than serve a single organization or interest group.

Professional training. The number of ACS-approved departments increased by six in 1979 to a total of 553. Whereas the number of bachelor's degrees awarded by these departments continued to rise slightly, the number of master's degrees declined. The number of doctorates remained the same as in the previous year. The 1979 edition of the "Directory of Graduate Research," published biennially, was issued in October. Plans for converting the preparation of the fifth edition of "College Chemistry Faculties" to a computerized process were completed, with publication scheduled for fall 1980. Future editions are to be published on a biennial basis.

Career services. A series of articles entitled "Career Options in Chemistry" was introduced in 1979. The articles outline basic facts about a variety of career specialties open to chemists, and feature profiles of people in each field. Two articles were published in 1979, and the series will continue through spring 1982. Also added to the catalog of career publications was "Graduate Programs in Chemistry," a booklet that describes advanced degree programs and lists schools that offer these programs. Career Services distributed about 14,000 copies of 13 career guidance publications in response to requests for specific titles; in addition, more than 3000 individuals, schools, public libraries, and teachers were sent packets of at least 10 publications in response to requests for career information.

Continuing education. ACS Short Courses continued to provide chemists and chemical engineers with the opportunity to learn from some of the nation's top scientists and educators. In 1979, 49 topics were presented for a total of 76 public sessions, the largest number offered in a single year since the program began. Total enrollment for the year was 3000. Since the program's inception in 1965, some 40,000 chemical scientists and engineers have attended.

The ACS Audio Courses program grew markedly; course distribution increased 50% over the previous year, and nine new courses were released, bringing the catalog of titles to 52. Firm author commitments for 40 additional courses were in hand at year's end.

An audio/print unit based on the Einstein Symposium sponsored by the ACS Division of Chemical Education during the 1979 fall national meeting went into production and will be released in mid-1980. Part II of Polymer Science & Technology, an ACS Correspondence Interaction Course, was released.

"Young Chemists: In Transition," a film produced by the ACS Younger Chemists Committee, was added to the ACS Film/Video catalog. The video portion and the reference manual of the course on Chemical Engineering for Chemists were completed for release in early 1980. In addition, a new course, Thermal Methods of Analysis, and the second edition of Interpretation of Infrared Spectra were in production in 1979 and are scheduled for 1980 release.

Eight Project CEDS (Continuing Education Delivery Systems) courses were in preparation, with four using video techniques and four using computer systems, including PLATO. Through an agreement with Control Data Corp., several business-related PLATO courses were made available to ACS members at 50 locations throughout the country.

Education of the handicapped. ACS was awarded a National Science Foundation grant for a project entitled "The Physically Handicapped in Science." The project, which seeks to develop guidelines for teaching chemistry to handicapped students, will be completed in 1980.

LOCAL SECTIONS

Energy, safety, continuing education for members, and programs for high school chemistry students and teachers were the principal concerns of the society's 178 local sections in 1979. They also continued to emphasize popular presentations of scientific topics at their meetings, including alternate energy sources, chemical oceanography, forensic chemistry, color photography, cancer chemotherapy, and "art and alchemy." The sections increasingly sought to bring chemistry closer to the public through sponsorship of museum exhibits, technology shows, a science documentary for radio, public lectures, radio public service announcements, and the planetarium show "The Loneliness Factor."

Twenty-three Program Development Fund grants totaling nearly $13,000 were made to sections in 1979 to support innovative activities, including chemical safety workshops, lecture-demonstration programs, a videotape production, and a careers program for high school students.

Winners of the ACS Award for Outstanding Performance by Local Sections were, in the four size categories, Akron (large), Eastern New York (medium large), Central North Carolina (medium small), and Wilson Dam (small).

As of July 1, ACS members and national affiliates assigned to local sections totaled 106,554, an increase of some 1500 over 1978. The sections were represented by 364 councilors during the year. More than 30 sections participated in a program, new in 1978, wherein the ACS national office collects section dues.

The Local Sections Speaker Service arranged some 90 lecture tours for about 150 sections and subsections involving more than 370 lectures. The typical tour consisted of four section visits at a cost of about $155 per engagement, as compared with $140 in 1978.

Two sections—Georgia and Wichita—celebrated their 50th anniversaries during 1979, and three marked their 25th—Eastern North Carolina, Indiana-Kentucky Border, and Santa Clara Valley.

DIVISIONS

Membership in the society's divisions increased overall 2.4% in 1979, and all but eight of the 31 divisions showed individual increases. The largest rise was 224 or 8% for Industrial & Engineering Chemistry; the largest drop, 109 or 17% for Chemical Marketing & Economics.

Permanent status was granted the Division of Chemical Health & Safety at the fall meeting in Washington, bringing the total number of full-status divisions to 29. In addition, the Divisions of Geochemistry and Small Chemical Businesses continued in their probationary period. The ACS Board of Directors made available $175,000 for support of divisions in 1979; of this, $167,861 was distributed.

Samuel E. Horne Jr. of B. F. Goodrich in Brecksville, Ohio, was

ACS division members and affiliates (paid only) as of Dec. 31, 1979

Division	Members 1978	Members 1979	Division affiliates 1978	Division affiliates 1979	National affiliates 1978	National affiliates 1979
Agricultural & Food Chemistry	1,192	1,247	161	167	0	1
Analytical Chemistry	4,205	4,219	182	181	2	6
Biological Chemistry	2,917	2,887	10	9	2	2
Carbohydrate Chemistry	653	660	2	0	0	0
Cellulose, Paper & Textile	619	641	58	60	0	1
Chemical Education	2,702	2,643	233	207	2	3
Chemical Health & Safety	323	454	48	46	0	0
Chemical Information	841	848	114	109	7	6
Chemical Marketing & Economics	634	525	240	187	2	0
Colloid & Surface Chemistry	1,218	1,291	115	184	1	1
Computers in Chemistry	519	548	22	18	2	2
Environmental Chemistry	1,489	1,580	105	130	1	0
Fertilizer & Soil Chemistry	342	334	6	5	2	1
Fluorine Chemistry	356	363	25	29	0	0
Fuel Chemistry	824	874	7	14	0	0
Geochemistry (Prob.)	20	105	0	14	0	0
History of Chemistry	244	270	33	36	0	0
Industrial & Engineering Chemistry	2,798	3,022	0	4	1	5
Inorganic Chemistry	2,133	2,205	46	39	0	0
Medicinal Chemistry	2,911	2,946	438	422	1	0
Microbial & Biochemical Technology	632	686	161	188	1	1
Nuclear Chemistry & Technology	761	757	118	152	2	1
Organic Chemistry	4,597	4,715	1	2	1	0
Organic Coatings & Plastics Chemistry	2,695	2,660	243	202	4	4
Pesticide Chemistry	1,069	1,104	212	238	1	1
Petroleum Chemistry	1,685	1,714	126	140	2	3
Physical Chemistry	2,044	1,960	29	36	0	0
Polymer Chemistry	4,130	4,195	489	477	0	0
Professional Relations	525	516	0	0	0	0
Rubber Inc.	1,996	2,146	1894	1837	0	0
Small Chemical Businesses (Prob.)	7	113	0	12	0	0
TOTAL	**47,081**	**48,228**	**5118**	**5145**	**34**	**38**

named winner of the Rubber Division's 1980 Charles Goodyear Medal for his work with Ziegler catalysts in the polymerization of butadiene and isoprene. The announcement was made at the division's October meeting in Cleveland.

The annual Divisional Officers Conference was augmented by a special Long-Range Planning Workshop for Divisions, funded by the ACS Science Commission (experimental) and organized by the council Committee on Divisional Activities. The council Committee on Meetings & Expositions sponsored the Seventh Annual Program Coordination Conference.

EMPLOYMENT AIDS

An improvement in the job market during 1979 was indicated by statistics from the society's employment clearinghouses. Applications on file in the year-round clearinghouse in Washington declined; at 622 down 8% from 1978's 771. Clearinghouses at the two ACS national meetings in 1979 averaged a ratio of job seekers to employers of 1.6, down from 1.9 in 1978, with totals for the national meeting clearinghouses as follows:

	High year 1960	Low year 1971	1978	1979
Candidates	796	1048	775	698
Employers	1965	297	500	437
Interviews	12,689	1152	2821	2438
Interviews/candidates	16.0	1.1	3.6	3.5
Candidates/employers	0.4	3.5	1.6	1.6

For the first time, a National Employment Clearing House also was operated at a regional meeting—the 11th Central Regional Meeting at Columbus, Ohio. This accounted for an additional 83 candidates, 41 employers, and 200 interviews.

At the Washington clearinghouse, the files were searched 413 times (444 in 1978) and 3357 résumés (3128 in 1978) were mailed to employers. Employers requesting searches in 1979 were classified as follows: industrial 263, academic 36, government 11, others 103. Positions open, grouped by broad fields, ranged from a high of 63 for analytical chemistry to five for clinical chemistry. Organic was second highest with 59, followed by polymer with 49.

Employer use of "Academic Openings" increased for listings placed by universities—195 vs. 187 in 1978. Positions listed at 217 were up 9% from 187 in 1978. In July, both "Academic Openings" and "Newspaper Clipping Service" became subscriber items; both continued to gain new subscribers. There were 12 issues of the former in 1979.

The Employment Aids Office processed 546 free "situation wanted" ads placed in C&EN by unemployed members in 1979, up from 531 in 1978. Responses to the ads were forwarded to the members (9323 vs. 11,584 in 1978). An additional 2437 went to employers using box numbers (3447 in 1978). The Confidential Employment Listing remained steady, with 80 members and seven employers registered at year's end. The $300 yearly retainer plan that provides all employment services was purchased by 43 employers, up from 25 in 1978.

MEETINGS AND EXPOSITIONS

Records toppled at the ACS/Chemical Society of Japan Chemical Congress in April in Honolulu, where 4919 papers were given by 10,641 authors at 672 sessions—all new highs. Attendance, at 9375, also was high for a spring national meeting. Attendance for the year, including the fall national meeting in Washington, D.C., totaled 19,321, up sharply from 1978's 13,411 and close to the 19,664 recorded in the Centennial year of 1976. Registrations at the year's nine regional meetings totaled 6524, down from the record 7789 in 1978, probably the result of increased interest in the national meetings. An experiment that proved successful at the Midwest Regional Meeting was the presentation of all con-

ACS national meetings, 1978–79

	Registration	Papers	Divisions	Sessions	Authors
175th (1978) Anaheim, March 12–17					
Total[a]	6846	2148	24	344	4,275
One-day sessions	651				
Advance registrations	4324				
Unemployed	20				
176th (1978) Miami Beach, Sept. 10–15					
Total[a]	6565	2400	28	408	4,870
One-day sessions	469				
Advance registrations	5002				
Unemployed	30				
177th (1979) ACS-CSJ Chemical Congress Honolulu, Hawaii, April 1–6					
Total[a]	9375	4919	28	672	10,641
One-day sessions	99				
Advance registrations	8066				
Unemployed	109				
178th (1979) Washington, D.C., Sept. 9–14					
Total[a]	9946	3050	30	461	6,355
One-day sessions	1123				
Advance registrations	6580				
Unemployed	93				

[a] Includes one-day-session registrations.

1979 ACS regional meetings

Meeting and location	Dates	Number of half-day sessions	Number of papers	Attendance
13th Middle Atlantic West Long Branch, N.J.	March 20–23	65	322	1068[a]
11th Central Columbus, Ohio	May 7–9	38	262	955
13th Great Lakes Rockford, Ill.	June 4–6	46	361	637
34th Northwest Richland, Wash.	June 13–15	33	179	526
9th Northeastern Syracuse, N.Y.	Oct. 2–5	41	285	650
15th Western[b] Pasadena, Calif.	Oct. 10–12	39	243	760
31st Southeastern Roanoke, Va.	Oct. 24–26	48	383	828
15th Midwest St. Louis	Nov. 8–9	6 symposia 18 poster	22 195	608
35th Southwest Austin, Tex.	Dec. 5–7	33	253	492
TOTAL			**2505**	**6524**

[a] Plus 150 high school students. [b] Joint with the Southern California Section of the Society for Applied Spectroscopy.

tributed papers within poster sessions mounted inside the perimeter of an accompanying chemical exposition.

Every seven years, ACS hosts the annual Intersociety Energy Conversion Engineering Conference, which directly involves the ACS Divisions of Fuel and Petroleum Chemistry. In 1979, ACS made arrangements for some 1000 registrants and published a 2372-page proceedings. ACS staff members for the second time managed the annual U.S./U.S.S.R. Joint Symposium on Chemical Catalysis.

In its first full year of operation, the new Chemical Expositions Department sold some 275 booths: slightly more than 100 at the Honolulu congress and 174 at the Washington fall meeting. An airline strike coupled with the offshore location made for a disappointing turnout in Honolulu.

PROFESSIONAL RELATIONS AND MANPOWER STUDIES

ACS concern for the professional well-being of chemists and chemical engineers in 1979 was exemplified by actions taken by the Committee on Professional Relations (CPR) and coordinated through the Office of Professional Relations (OPR). One of these, a statement espousing enactment of severance pay legislation in the U.S., was developed and adopted by CPR on the basis of its study of severance pay practices in other countries. The statement, accompanied by the study report, was transmitted to the ACS Board of Directors in the fall and was scheduled for board committee review at year's end.

Also referred to the board was a recommendation that CPR administer the ACS Legal Aid Loan Program. CPR's Subcommittee on Member Assistance began revising the lending guidelines. The Subcommittee on Professional Standards in 1979 began development of an employer recognition program to promote the society's "Professional Employment Guidelines."

A statement prepared by CPR's Subcommittee on Hazards & Toxins, concerning problems of environmental hazards and toxins, carried in the Sept. 17, 1979, issue of C&EN, elicited many comments from members for CPR's consideration in recommending appropriate ACS action. CPR resumed providing local section publication editors with articles about developments in professional relations, and three were made available during the year.

Mutually beneficial contacts with appropriate government offices were strengthened by the Subcommittee on Civil Service Liaison in 1979. The special counsel of the Merit Systems Protection Board attended the subcommittee's September meeting and discussed the functions of that office in protecting whistle-blowers in federal service. In December the subcommittee met with four high-level representatives of the U.S. Office of Personnel Management to discuss concerns pertaining to chemists and chemical engineers in the Civil Service.

OPR gathered information on 14 layoffs of chemists and chemical engineers reported in 1979, a decrease of two from 1978. A committee report on 13 layoffs involving 131 chemists and chemical engineers (for which information was gathered in 1978) appeared in the Jan. 22, 1979, issue of C&EN, and an article (prepared by C&EN staff members based on a CPR report) on six layoffs involving 60 chemists and chemical engineers appeared in the Nov. 26, 1979, issue.

OPR received 11 formal requests for member assistance in 1979—six more than in 1978. During the year, 12 member assistance cases were reviewed by CPR's Subcommittee on Member Assistance and three cases were closed.

Other activities of CPR and OPR included rewriting two professional relations publications—"Employment Agreements" and "Trade Secrets. . .Ethics and Law"—and supplying the Professional Orientation Seminar (materials to help prepare graduating chemists for industrial employment) to 15 chemistry departments or student affiliate chapters representing some 800 students. CPR cooperated with the ACS Division of Professional Relations in presenting two symposia and a professional relations caucus at ACS national meetings.

The society's Office of Manpower Studies (OMS) filled a request for information concerning compensation for employed inventors by adding several questions to its annual survey of the ACS membership. OMS also began a project to learn how academic chemists use computers in their research and what kinds of computers they use. In cooperation with the council Committee on Economic Status, OMS helped other committees, local sections, and ACS staff offices to conduct surveys and analyze results.

Early in 1979, OMS published the society's fifth annual statistical report on chemical manpower, "Professionals in Chemistry: 1978." Other projects included surveys to obtain information about salaries and employment, both of experienced chemists and of chemistry and chemical engineering graduates, and publication of the *OMS Bulletin*, which gives the results of special OMS studies on compensation of chemists and chemical engineers.

RESEARCH GRANTS & AWARDS

PETROLEUM RESEARCH FUND

ACS received more than $6.7 million from the Petroleum Research Fund Trust in 1979 "exclusively for advanced scientific education and fundamental research in the 'petroleum field,' which may include any field of pure science which . . . may afford a basis for subsequent research directly connected with the petroleum field." These funds permitted the commitment of $6,018,576 for new grants in the various programs in effect during the year (see accompanying table).

The ACS-PRF grants program continues to emphasize modest grants-in-aid to colleges and universities in support of faculty research with students and postdoctoral fellows. Flexibility in the use of funds to achieve the objectives of the research project is an important feature. Two programs, the ACS-PRF Type B program of grants for fundamental research in "undergraduate departments," and the Type G, "Starter" grant program for beginning faculty researchers, are intended to meet needs which are deemed especially critical. Because ACS-PRF grants are grants-in-aid in support of ongoing programs of research and education, grantee

Glenn T. Seaborg, Lawrence Berkeley Laboratory, accepts Priestley Medal from ACS president Gardner W. Stacy

institutions, such as universities, are willing to administer them without overhead or administrative charges. This mutually beneficial system enables PRF funds to assist more research than they would if the full cost of research had to be paid.

During 1979 the ACS Board of Directors voted, upon recommendation of the PRF Advisory Board, to discontinue ACS-PRF Grants for New Directions in Fundamental Research. The advisory board recommended that available funds be committed to the ACS-PRF Type AC program instead. In 1978 and 1979 a total of $651,426 was devoted to eight "New Directions" grants. Other ACS-PRF programs continued in effect under the terms stated in the 1978 ACS annual report.

The "23rd Annual Report on Research under Sponsorship of The Petroleum Research Fund," published in May 1979, contained 672 technical progress reports on PRF-assisted projects for the year ending Aug. 31, 1978, and a bibliography of 859 articles acknowledging PRF support. As is customary, copies of the report were distributed to the donors of the trust, principal investigators on PRF projects, libraries, members of the research community, and the public at large.

Distribution of 1979 funds authorized for new and continued ACS-PRF grants

Type of grant	Number of proposals submitted	Number of grants recommended[a]	Amount recommended	% of total funds
AC	451	136	$ 4,051,904	67.3
B	111	46	593,872	9.9
G	206	111	1,110,000	18.4
SEO	39	22	68,800	1.1
New Directions	32	2	194,000	3.2
TOTAL	**839**	**317**	**$ 6,018,576**	**100%**

[a] Listed in C&EN Jan. 8, 1979, page 35; April 3, 1979, page 56; and June 18, 1979, page 33.

AWARDS ADMINISTERED BY ACS

The Priestley Medalist for 1979 was Glenn T. Seaborg, Lawrence Berkeley Laboratory, University of California, Berkeley. Other recipients of 1979 ACS Awards were announced at the fall 1978 national meeting (C&EN, Sept. 11, 1978, page 42). Recipients of 1980 ACS Awards were announced at the fall 1979 national meeting (C&EN, Sept. 10, 1979, page 62).

The ACS Board of Directors accepted the offer of an anonymous donor to sponsor the ACS Award for Nuclear Chemistry on a biennial basis beginning in 1981, for five presentations. In even-numbered years the award is sponsored by EG&G ORTEC. The Peter Debye Award in Physical Chemistry, last presented in 1976, was reinstated with E. I. du Pont de Nemours & Co. as its new sponsor. The first presentation under Du Pont's sponsorship will occur in 1981. The ACS Award for Creative Invention sponsored by the Corporation Associates, the ACS Award in Petroleum Chemistry sponsored by Lubrizol Corp., the ACS Award in the Chemistry of Plastics & Coatings sponsored by Borden Foundation, and the James Flack Norris Award in Physical Organic Chemistry sponsored by the ACS Northeastern Section were renewed by their sponsors.

The Priestley Medalist for 1980 is Milton Harris (C&EN, July 9, 1979, page 30).

SCHOLARSHIPS ADMINISTERED BY ACS

The society awarded George E. Frederick Jr. Scholarships of $1000 each to students selected by three colleges that administer the scholarships under agreements with ACS: Beloit College, Coe College, and Pomona College.

BOOKS & JOURNALS

Despite unchecked inflation on the national scene, the Books & Journals Division had a successful year financially in 1979. Revenues increased substantially, primarily from subscriptions, book sales, and short-term investments. The financial prospects for the division looked good enough that the ACS Board of Directors approved another reduction in the page charge rate for the research journals in 1980.

Book publishing activities expanded to 44 new titles this year, as compared with 34 in 1978. The current number includes 12 volumes in the Advances in Chemistry Series, 29 in the ACS Symposium Series, and three other titles.

Unit sales of books increased 28% to a new high of 70,152 copies—including 1886 copies of books published by The Chemical Society (London). Gross sales revenue for the Books Department rose 24% over 1978, to $1.3 million. Royalties paid to ACS divisions on sales of symposium books increased 42% to $49,407.

Outstanding in 1979 were large shipments of standing orders for new titles in the Advances in Chemistry Series and the ACS Symposium Series to the People's Republic of China. Meanwhile, distribution agreements with West Germany, Japan, and the U.K. continued to operate successfully.

The computer photocomposition of two additional journals—*Biochemistry* and *The Journal of Organic Chemistry*—was transferred from Mack Printing Co. to the society's Chemical Abstracts Service division. The conversion schedule will be completed when the photocomposition of *Chemical Reviews* and the *Journal of the American Chemical Society* is transferred in 1980.

Four special issues of *The Journal of Physical Chemistry* were published during 1979. Three of the issues were dedicated to specific individuals—Don Louis Bunker, E. Bright Wilson Jr., and Sam I. Weissman. The other special issue contained most of the papers presented at a symposium on the current status of the kinetics of elementary gas reactions held at the National Bureau of Standards in June 1978.

In 1979 the *Journal of the American Chemical Society* completed 100 years of uninterrupted publication. The anniversary was celebrated at a dinner held during the national ACS meeting in Washington, with the current editor, Cheves Walling, and three former editors, W. Albert Noyes Jr. (the featured speaker), Marshall Gates, and Martin Stiles, in attendance.

Jerome A. Seiner was named editor of *Industrial & Engineering Chemistry Product Research & Development* following the untimely death of Howard L. Gerhart, who had served as editor since 1968.

The Subcommittee on Journals Monitoring, set up by the society Committee on Publications (with one member representing the Science Commission) to monitor the intellectual health of ACS journals, had four task forces at various stages of work during the year. The task force to monitor *The Journal of Physical Chemistry* completed its report and, at year's end, the group monitoring the *Journal of the American Chemical Society* was nearing the end of its deliberations, and task forces were named to monitor *The Journal of Organic Chemistry* and *Chemical Reviews*.

Herbert A. Laitinen served the last of his 14 years as editor of *Analytical Chemistry*, giving the reins over to George H. Morrison of Cornell University in 1980. In addition, a new position of executive editor was established to coordinate the editorial and business aspects of the publication, and continued emphasis in the magazine section was given to more practical problem-solving editorial material designed to meet the needs of the readers.

In 1977 the society Committee on Publications gave *Chemistry* magazine two years to establish its viability by substantially increasing its subscriptions and proving its acceptability to the public. In 1979, the magazine changed its name to *SciQuest* and radically revised its editorial policy. Subscriptions increased some

10,000 with many of them coming from members of the lay public. Because of the magazine's impressive performance, the board accepted the 1980–84 fiscal forecast for *SciQuest* as a five-year plan for operation of the magazine.

Environmental Science & Technology, which held a relatively constant circulation base in 1979, published more editorial pages and more advertising pages than in 1978. A market study to assess the editorial focus of *ES&T* was begun and scheduled for completion early in 1980.

CHEMTECH proved to be ahead of its time in selecting as its 1979 theme "The Innovative Process," a subject on which Congress and the White House spent a great deal of time during the year. *CHEMTECH*'s breadth was exemplified by the variety of subjects covered in its feature articles. They ranged from Pilkington's implementation of the float-glass process through Intel's development of integrated circuits to Zeocon's introduction of a variety of controlled-release drugs.

A 10-year retrospective study of the Microforms and Back Issues Program, completed in 1979, showed steady growth in both income and circulation. Income grew to $602,650 in 1979, compared with $157,800 in 1970. Microform customers, numbering 834 in 1970, totaled 4200 at year's end.

The division's sales office staff made 140 sales presentations at approximately 75 sites in 14 major U.S. cities. The installation of a 24-hour toll-free number (800-424-6747) and acceptance of Master Charge and Visa credit cards greatly enhanced the sale of the division's products.

Publications circulation development, funded from publications rather than membership dues, undertook some 80 direct-mail promotional campaigns involving more than 2.1 million pieces of mail. This activity accounted for more than 39,000 new subscriptions to ACS publications. In addition, a new subscription-renewal program that resulted in increased renewals for all the publications was implemented.

A separate program for audiovisual products was expanded in 1979. Direct-mail activity was begun in the second half of the year, and 37 tests providing information on product users were conducted. The division added 21 new titles, many of which are useful to scientific disciplines other than chemistry.

A final report was issued on the investigation of an alternative journal format—a "condensed" version of *JACS*, which contained the same communications and book reviews as the regular journal but only headings and author abstracts of the full articles. A large-scale mail questionnaire survey showed that 60 to 70% of existing *JACS* subscribers and about 75% of nonsubscribers favored publication of the condensed version in addition to the regular journal. However, the society Committee on Publications was concerned about possible adverse effects on *JACS* and disapproved the alternative form.

During the year, investigation of potential uses for the primary journal data base (created during the photocomposition process) continued, with emphasis on the on-line access to information contained in the journals' text. An on-line experiment will be conducted early in 1980.

A computer-based reviewer selection and manuscript control file for *Biochemistry* was designed, programmed, and installed in the editorial office. Personnel were trained in its operation and it was working successfully by midyear.

ACS publications data, 1979

Publication/editor	Total papers Received 1978	Total papers Received 1979	Total papers Published 1978	Total papers Published 1979	Editorial pages 1978	Editorial pages 1979	Paid subscriptions 1978	Paid subscriptions 1979	Subscription rates (domestic 1979) Member	Subscription rates (domestic 1979) Nonmember
C&EN, Michael Heylin	—	—	—	—	1916	2040	125,947	128,133	$10.35	$ 19.00
SciQuest	—	—	30	30	328.5	352.7	33,490	47,456	9.00[a]	12.00[b]
CHEMTECH, Benjamin J. Luberoff	—	350	—	111	786	796	15,614	15,291	17.00	25.00[c]
J. Phys. Chem. Ref. Data, David R. Lide	—	—	—	—	1812	1354	1,215	1,175	25.00	100.00
Anal. Chem., Herbert A. Laitinen	993	976	587	612	3115	3322	30,947	30,590	12.00	16.00[d]
ES&T, Russell F. Christman	311	338	167	181	1264	1,366	17,660	17,354	16.00	24.00[e]
Accounts Chem. Res., Joseph F. Bunnett	70	98	71	66	528	503	9,719	9,316	14.00	56.00
Chem. Rev., Anthony Trozzolo	28	33	22	21	682	602	5,454	5,473	17.00	68.00
I&EC Quarterlies										
Process, Hugh M. Hulburt	169	192	99	128	601	783	5,288	5,204	10.00	40.00
Fundamentals, Robert L. Pigford	148	149	72	88	393	463	5,142	4,967	11.00	44.00
Product, Jerome A. Seiner	81	161	76	79	395	400	5,004	4,853	10.00	40.00
JA&FC, Philip K. Bates	459	425	390	368	1533	1,482	5,030	5,090	12.00	48.00
JC&ED, Bruno J. Zwolinski	171	191	128	126	385	413	1,962	1,962	20.00	80.00
Biochemistry, Hans Neurath	1439	1448	894	900	6038	6,169	6,839	6,845	32.00	128.00
Inorg. Chem., M. Frederick Hawthorne	1009	1102	821	819	3854	3,760	4,716	4,721	36.00	144.00
JACS, Cheves Walling	3064	3060	1920	1790	8555	8,026	14,577	14,236	42.00	168.00
JCICS, Herman Skolnik	91	108	49	63	257	293	2,209	2,209	11.00	44.00
J. Med. Chem., Philip S. Portoghese	529	588	295	324	1432	1,649	4,350	4,308	21.00	84.00
J. Org. Chem., Federick D. Greene	1561	1687	1361	1330	5261	5,240	9,892	9,997	32.00	128.00
J. Phys. Chem., Bryce Crawford Jr.	871	1069	607	677	3017	3,637	4,625	4,502	32.00	128.00
Macromolecules, Field H. Winslow	334	410	274	279	1346	1,286	2,378	2,373	24.00	96.00
Books Department, M. Joan Comstock	741	625	529	691	8980	13,707	—	—	—	—

a All individuals. **b** Institutions. **c** Nonmember personal use; price to institutions is $85. **d** foreign, except Canada, $18. **e** Nonmember personal use; price to institutions is $64.

ACS meeting in Hawaii...

Delegation from People's Republic of China attended meeting in Honolulu

Board chairman William Bailey at council meeting

ACS president Gardner Stacy presided over opening ceremonies

. . . and in Washington

President-elect James D'Ianni at council meeting

Former JACS editor W. Albert Noyes Jr. addresses JACS 100th anniversary celebration

Membership booth at ACS exposition

Board member Pauline Newman

CHEMICAL ABSTRACTS SERVICE

Chemical Abstracts Service in 1979 continued to expand marketing activities and intensified efforts to identify and respond to needs for new information services that might be derived from the CAS data base and processing system.

During 1979 a formal new ventures operation was set up to evaluate and test ideas for new publications and services; a field sales force was organized and trained; an international marketing office was opened in Frankfurt, West Germany; pricing and marketing policies for existing publications and services were reevaluated and altered where appropriate; and advertising and promotion efforts were stepped up. Partly as a result of expanded marketing efforts, 1979 revenues exceeded projections.

Particular emphasis is being given to identifying and developing "customer-defined" services that can be derived readily from the CAS data base. Two such services were produced during 1979. In one, CAS provides two special bulletins of abstracts for Exxon Research & Engineering Co. The contents of these bulletins are selected by computer searches of the CAS data base with profiles that define Exxon's specific interests in two broad chemical areas. In the other, CAS is helping scientists and engineers in a number of companies in the petroleum industry to keep abreast of new developments in petroleum chemistry, energy technology, and related chemical and chemical engineering topics by searching the computer files of information processed for current issues of *Chemical Abstracts* and selecting from them abstracts of interest to particular individuals. Computer printouts of selected abstracts are mailed to participants every two weeks.

CAS also continued to expand its *CA Selects* service, which makes abstracts of current publications and patents on specific chemical and chemical engineering topics available in inexpensive biweekly bulletins. The number of topics included in the service increased from 76 in January 1979 to 110 in January 1980.

One result of the re-evaluation of marketing and pricing policies is an experiment in which small colleges are being offered grants of up to $4000 toward purchase of *Chemical Abstracts* and certain other CAS publications and services. The grants are expected to bring CAS publications and services within the reach of hundreds of colleges that could not otherwise afford them and give more undergraduate students an opportunity to become familiar with them (C&EN, Jan. 28, 1980, page 55).

To provide greater flexibility in responding to the changing environment in which it now operates, CAS in 1979 consolidated its internal operations into four organizational units: Publications and Services, which combines document acquisition and selection, editorial operations, and data processing and production operations; Research and Development; Marketing; and Business Administration. Decision-making responsibility has been centralized in a seven-member management board.

CAS is working on a computer system that promises to make on-line searching of the Chemical Registry possible

The number of documents cited in *Chemical Abstracts* passed the half-million mark for the first time in 1979. A total of 515,741 papers, patents, and other documents was cited during the year, an increase of 3.4% over 1978.

Structure records of 346,062 new substances were added to the files of the CAS Chemical Registry System during 1979. The total number of substances in the registry files was approaching 4.8 million at year's end. The associated nomenclature file contained almost 7.5 million names.

CAS continued to operate private registries for the National Cancer Institute and the Warner-Lambert/Parke-Davis pharmaceutical research division. Work began during the year on the development of another private registry for a large industrial organization.

Late in the year, CAS received a grant from the Council on Environmental Quality, the Environmental Protection Agency, and the National Library of Medicine to study the feasibility of adding chemical substances indexed in *Chemical Abstracts* prior to startup of the registry in January 1965 to the registry files. Numerous substances, possibly numbering in the millions, were indexed prior to 1965 and have not been mentioned in the literature since. Registering substances from earlier *CA* indexes would enhance the registry's usefulness by making it a nearly complete listing of known substances.

Work continued on the development of a system that promises to make it possible to search the registry files on-line to identify substances that contain particular combinations and arrangements of atoms and bonds embedded within their structures. A pilot version of this substructure search system is expected to be in experimental use during the last half of 1980.

Research and exploratory work in other areas was expanded significantly in 1979, focusing both on ideas and techniques applicable to new services and on procedures for further automating information processing at CAS. Studies were under way on approaches to providing automated assistance to searchers in formulating information-retrieval queries and on possible applications of computer translation of chemical names to connection tables as a technique for entering substructure search questions in a computer search system. Work also was under way on an automated patent processing support system that will draw upon computer files created by the International Patent Documentation Center in Vienna to select patents for coverage in the CAS data base. The research and development staff also undertook a major

Chemical Abstracts publication record, 1970–79

Year	Volume	Documents cited	Pages[a]
1970	72,73	309,742	48,713
1971	74,75	350,105	51,585
1972	76,77	379,048	54,054
1973	78,79	356,549	51,696
1974	80,81	375,663	52,984
1975	82,83	454,245	62,969
1976	84,85	458,508	65,591
1977	86,87	478,225	68,496
1978	88,89	498,559	68,638
1979	90,91	515,741	73,343[b]

a Includes pages in volumes of abstracts published during the indicated year plus pages in the volume indexes for those abstract volumes, some of which are published in the year following that in which the volume of abstracts appears. **b** Includes estimate of pages in indexes for Vol. 91, which will be published during 1980.

study of automatic spelling error detection and correction in large data bases under a National Science Foundation grant.

Work was completed early in the year on the Toxic Substances Control Act Initial Inventory, which CAS compiled under contract for the Environmental Protection Agency. Registry files and substance identification techniques were used to identify 43,278 unique substances for the initial inventory from among more than 120,000 individual reports submitted by industry on substances manufactured or imported for commercial use in the U.S. A supplement to the inventory issued later in the year listed another 2928 substances.

On Sept. 1, the Japan Association for International Chemical Information assumed responsibility for the marketing and distribution of all CAS publications and services in Japan. The Japanese organization had been marketing CAS computer-readable files in Japan since 1977 under an agreement that called for it to take over the marketing of all CAS publications and services once it had built up the necessary staff and resources.

Internationale Dokumentationsgesellschaft fur Chemie in West Germany, the Chemical Society in the U.K., and France's Centre National de l'Information Chimique continued to pay a share of CAS operating costs and market CAS publications and services in their nations under cooperative agreements. The Chemical Society Information Services also prepared abstracts and index entries for British papers and patents for input to the data base.

CAS received its first order for computer-readable files from the People's Republic of China during 1979. The Chinese Society for Chemical Industry in Beijing requested and was granted licenses to use five CAS files. Exchanges of journals with Chinese scientific and technical organizations also continue to expand. At year's end CAS was receiving 49 Chinese journals, and another 38 had been identified and requested.

OTHER ACS OPERATIONS

CHEMICAL & ENGINEERING NEWS

During 1979 C&EN staff members worked to improve the magazine's week-to-week coverage of chemical science and technology, of the chemical industry, and of the federal government's impact on all aspects of the chemical world. The year also brought a major effort to upgrade the magazine's coverage of the broader aspects of the interface between chemistry and the chemical profession on the one hand, and society at large on the other. This involved expansion of the magazine's program of special reports and news features.

In moving in these two directions the magazine met the editorial objectives it set for itself for 1979. For instance, the first edition of "Facts & Figures of Chemical R&D" was published in the July 23 issue. This detailed analysis of data on this country's R&D effort, especially in chemistry, will become a permanent addition to the magazine's series of annual statistical presentations. The Nov. 23 issue contained an extensive preview of "Chemistry in the 1980's." This carried articles by George Hammond, William O. Baker, Ralph Landau, Carl Gerstacker, and Alan McClelland. During the year the magazine also revived its News Forum series with a debate in print, in the April 23 issue, of the issue of "Has environmental regulation gone too far?"

Other special reports published during the year were concerned with photosynthesis and plant productivity, hydride reductions, nutrition and health, fusion power, photochemistry, hazards of the chemical industry, and the chemical industry in China. And staff-written news features covered nuclear waste disposal, Dow Chemical's analytical work on dioxin, chemical waste disposal, the social thermodynamics of Ilya Prigogine, politics and the world's raw materials, synfuel developments, and the ozone layer.

Late in the year the magazine boosted its editorial staff to 27 with the addition of new staff members to the groups reporting on both government activity and on science and technology. Also late in the year the position of business manager was created and staffed.

Financially the magazine continued in sound condition in 1979. A substantial increase in income from advertising kept C&EN in the black for the fourth consecutive year.

PUBLIC AFFAIRS

1979 was a year of change and transition in the Department of Public Affairs (DPA). A major reorganization consolidated the former Department of Chemistry & Public Affairs and the Department of Public & Member Relations into one new Department of Public Affairs (DPA), under the direction of Robert G. Smerko. Staff responsibilities also were reorganized to some extent. These actions were taken to enhance the effectiveness of the society's public affairs activities.

Federal regulatory activity. The department worked to develop better communications with ACS divisions that have special interests in federal regulations. The Divisions of Analytical Chemistry, Environmental Chemistry, Industrial & Engineering Chemistry, Medicinal Chemistry, and Pesticide Chemistry established liaisons with DPA in 1979.

DPA assists the divisions by monitoring pertinent regulatory issues and keeping the divisions informed of their current status; informing the divisions of pertinent ACS activities; alerting them to possible ACS nominations for membership on federal advisory boards, committees, and other outside groups; and transmitting to the divisions the department's biweekly *Washington Alert*.

Intersociety review of federal R&D budget. ACS participated for the first time in a review of funding for R&D in the President's budget for fiscal year 1980, sponsored by the American Association for the Advancement of Science. Two reports were prepared on this subject in 1979.

ACS policy statements and communications. During 1979, ACS issued 19 board-approved policy statements. Six of these went to regulatory agencies, including three to Douglas Costle, Environmental Protection Agency Administrator, to give ACS's views on EPA's plans for implementing various portions of the Toxic Substances Control Act (TSCA).

In the legislative arena, three statements to various Congressional committee chairmen explained ACS's view that a uniform federal patent policy is needed; ACS president Gardner W. Stacy re-emphasized this point in testimony before the House Subcommittee on Science, Research & Technology on Oct. 17.

Several statements dealt with federal budgetary matters—increased funding for the Patent & Trademark Office was recommended, as well as restoration of postharvest technology research funds cut from the Department of Agriculture budget. Support for the President's increase in research funding, and support for continuation of the type of long-term research supported by the National Science Foundation's "Chemical Threats to Man and the Environment" program rounded out ACS's comments on the federal 1980 budget.

Other ACS statements supported a proposed National Academy of Sciences study on establishing a uniform federal cancer policy; opposed transfer of the NSF Science Education Directorate to the new Department of Education; called for an incentives program to encourage private investment in R&D, which would thereby stimulate industrial innovation; supported by Sen. Kennedy's bill on equal opportunity for women in science and technology; and, finally, expressed some concerns about the "National Publications Act of 1979" that had been voiced by the membership.

Member-related programs. DPA made a special effort in 1979 to encourage greater involvement by the ACS membership in public affairs activities of the society. Two DPA programs are designed to bring this about: the Congressional science counselor program and the local section public affairs coordinator program.

Several steps were taken to strengthen the Congressional science counselor program. A bimonthly *CSC Newsletter*, which began publication in February, contains information on such subjects as "Getting to Know Your Legislator" and the makeup of the 96th Congress. An article on "Lobbying and the CSC Program" explained what the counselors can and cannot do in working with their legislators in order not to violate the tax rules ACS operates under as a nonprofit scientific and educational organization.

Early in 1979 the sections were asked to appoint public affairs coordinators to serve as contacts in the sections on public affairs matters. Suggestions and information are sent to the coordinators to assist them in their public affairs work. Attention was called to the new ACS bylaw IX, which explains procedures by which ACS units can issue their own policy statements. In turn, the sections are encouraged to call ACS's attention to matters in which they think the society should be involved.

Short articles on public affairs topics also are sent to section newsletters for publication. Articles to date include one on how ACS policy statements are developed, and one on environmental action in local communities. Information packets are put together for distribution at local section conferences to acquaint incoming section chairmen with DPA's programs and activities.

DPA publications. A study titled "Chemistry and the Food System" was written in 1979 and will be published in March 1980. It covers the entire spectrum of chemistry's role in the food system from farm to table.

Public affairs symposia. Two public affairs symposia transcripts were published during the year—"Materials and National Policy" and "Food from the Chemical Viewpoint." The "food" symposium was especially well received, and the initial press run has since been exhausted. A symposium on "Science and Technology Policy in Japan and the United States" was held at the spring national meeting in Honolulu.

Fellowship program. The ACS fellows for 1979–80 are David L. Eck, chairman of the department of chemistry at Sonoma State University, and Stephen D. Ziman, a senior research chemist at Chevron Chemical Co. The fellows have accepted staff positions on Capitol Hill with the House Committee on Science & Technology. Eck is working with the Subcommittee on Energy Development & Application, and is responsible for the Biomass Research & Development Authorization Act. Ziman has been working on the issue of innovation and productivity, and on various authorizations.

Environment. The ACS Committee on Environmental Improvement (CEI) will sponsor jointly with the Division of Environmental Chemistry a series of symposia on the chemical aspects of energy use, to be held at future national meetings. CEI also has developed a priority list of actions in the areas of air, water, wastes, pesticides, radiation, and chemical monitoring and analysis. The list will be used as the basis for future committee involvement.

CEI worked on its "Guidelines for Data Acquisition and Data Quality Evaluation in Environmental and Trace Analytical Chemistry," which establish minimum requirements for reliable chemical analysis of environmental samples with emphasis on trace organic analysis. The guidelines include minimum requirements needed to obtain data that are likely to satisfy validation criteria such as precision, accuracy, and limits of detection.

DPA staff began to identify ACS members whose principal area of interest is the environment in order to develop a roster of environmental chemists who would assist in reviewing proposed legislation and federal agency regulations, serve on government committees, and provide greater focus for the society's environmental actions.

PUBLIC RELATIONS

The society's second planetarium show, "Springtime of the Universe," premiered in June at the Hansen Planetarium in Salt Lake City and was released for general distribution in November. By year's end, several ACS local sections had built meetings around local showings. "The Loneliness Factor," the first ACS planetarium show, had been seen by nearly 16 million persons at some 500 planetariums worldwide by the end of 1979.

A science documentary for radio based on "The Loneliness Factor" and titled "Are We Alone in the Universe?" was carried on some 140 broadcasts heard by an estimated audience of 7 million. Many of the broadcasts were arranged or promoted by local sections. Two radio public-service announcements were distributed each month of the year to some 2800 stations, and a special series of these announcements for exclusive distribution by local sections was nearing completion by year's end. Topics included vitamins, lightweight clothing, synthetic lubricants, and "chemists are human, too." Man and Molecules, the oldest radio science series in the U.S., entered its 19th year of continuous production and was aired by some 500 stations to a weekly audience estimated at 6 million to 8 million.

The Washington national meeting gave rise to the largest number of newspaper clippings—2192, of which 251 were on page one—since the ACS Centennial in 1976, accounting for a near-record 32,618 column inches. These were based on both news releases and press conferences. By contrast, the Chemical Congress in Honolulu, because of its remote location and time differential, resulted in only 387 clippings, 11 page-ones, and 4277 column inches. Another 68 stories generated by the ACS News Service during the year resulted in some 1800 additional clippings; subjects included ACS national elections, award winners, regional meeting papers, and the Inter-Society Energy Conversion Engineering Conference.

One of the most popular made-for-TV film clips ever produced by the News Service was based on a paper given at the Washington national meeting that shed new light on the origin of life. This clip was telecast by all the major networks and was placed with many local TV stations by ACS local sections.

"The Chemist and the Public," a handbook for local section public relations chairmen, was revised and sent to the 1979 chairmen. Preliminary work began on a film about chemistry in medicine and on a new planetarium show on DNA and recombinant DNA. Roy Avery, head of the Public & Member Relations Department since 1973 and a staff member for 29 years, retired at year's end.

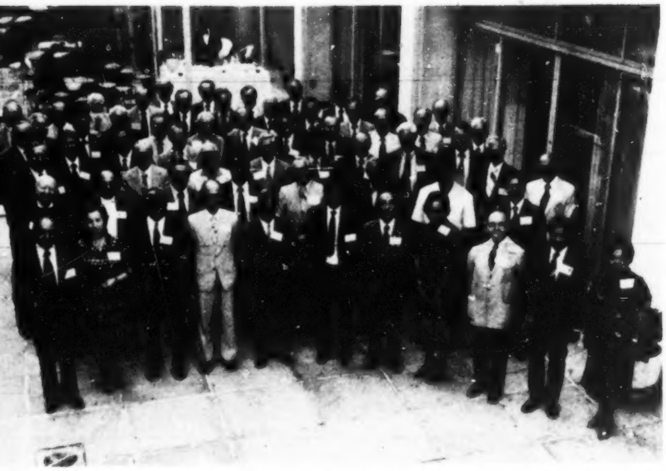
INTERNATIONAL ACTIVITIES

Immediately following the ACS national meeting in Washington, ACS served as host for the 7th International Meeting of Chemical Society Presidents. The meeting was organized by Gardner W. Stacy and a subcommittee of the society's International Activities Committee (IAC) composed of William J. Bailey (chairman), Robert B. Fox, Jesse C. H. Hwa, and Bryant Rossiter. Staff support was provided by the Office of International Activities. Thirty-six societies from 33 countries were represented, as were regional chemical associations in Africa, Asia, and Europe.

During the business meetings, the presidents discussed the role of chemistry and of chemical societies in the transfer of science and technology among nations, developments in the registration and licensing of chemists, relationships between universities and the chemical industry, and chemistry's role in the provision of energy.

Science and technology exchange/India. In April, the National Science Foundation approved a grant of $36,000 to ACS to support a workshop to be held in India in cooperation with the Indian Chemical Society. Devoted to natural products chemistry, organometallic chemistry, and solid-state chemistry, the 13-day workshop will be held in January 1980 to discuss the latest research in India and in the U.S. in the three subjects and to prepare proposals to seek support for research and development projects to be conducted in the two countries.

Science and technology exchange/Egypt. Two of eight research and development projects recommended during a workshop held late in 1977 in cooperation with Egypt's National Research Centre were implemented by the Agency for International



Presidents of 38 chemical societies from 33 countries attended 7th International Meeting of Chemical Society Presidents

Development in 1979. One deals with improvements in the process used in Egypt to scour wool and refine the recovered wool wax into useful products for markets in Egypt. The other is devoted to formulating corrosion inhibitors using native Egyptian raw materials, to lessening corrosion in Egypt's petroleum refineries, and to establishing a first-class corrosion research laboratory at the National Research Centre. Four Americans visited Egypt in January to help prepare detailed R&D programs for the two projects, and by late spring work began on both at the center's laboratories in Cairo.

International chemical society. At the ACS/CSJ Chemical Congress in Honolulu in April, IAC held an open forum during which chemists from a number of countries discussed formation of an international society to which chemists might belong as individuals. It also served as host at a dinner there during which presidents or representatives of chemical societies in 10 countries bordering the Pacific Ocean had a similar discussion. Support for the concept proved generally to be strong, although everyone agreed that skillful planning will be required to form a successful organization. The most significant single action taken during the chemical society presidents meeting, meantime, was agreement to establish an international committee to consider the formation of such a society.

Delegation from China. The Chinese Academy of Sciences accepted an invitation to attend the ACS/CSJ Congress and 12 directors and deputy directors of the academy's major institutes attended the meeting and then toured university, government, and industrial laboratories in eight states and Washington, D.C., during the two weeks following. Discussions also were held by the delegation's leaders and ACS officers and staff on ways in which contacts between the two organizations could be enhanced.

Scientific freedom/human rights. In September 1978, the board voted to accept the invitation of the American Association for the Advancement of Science to investigate cases of alleged violations of the scientific freedom and/or human rights of chemists in other countries. The first cases considered were those of Drahoslav Lím, a chemist seeking to be allowed to emigrate from Czechoslovakia, three chemists in Argentina who are reported to have been arrested but who have not been heard from since, and a chemist in the U.S.S.R. who wished to emigrate. Lím was allowed to emigrate in 1979, but the others' cases were unresolved at year's end.

Berzelius scroll. At the Washington meeting of chemical society presidents, ACS presented scrolls to attending presidents or their representatives in honor of the 200th anniversary of the birth of Jöns Jacob Berzelius. In December, Glenn T. Seaborg had a personal audience with His Majesty Carl XVI Gustaf, King of Sweden, and presented a special scroll on behalf of ACS honoring the famous Swedish chemist.

GOVERNING BODIES

BOARD OF DIRECTORS

Mary L. Good was elected chairman of the ACS Board of Directors for 1980 at the board's December meeting in Washington. She succeeds William J. Bailey, who in turn succeeded her in 1979. Other board members elected or re-elected in 1979 to three-year terms beginning in 1980 were Albert C. Zettlemoyer, president-elect; William J. Bailey and Robert W. Parry, directors-at-large; Gordon L. Nelson, Region I; and Bernard S. Friedman, Region V.

Brief summaries of the board's meetings in April and September appeared in C&EN for April 23, page 55, and Sept. 24, page 50. Official reports from the June and December meetings were in C&EN for July 16, page 27, and Jan. 21, 1980, page 58. In addition to actions reflected elsewhere in this report, the board also:

- Approved a modified $51 million 1979 general fund budget with a net deficit of $223,000.
- Approved a Petroleum Research Fund budget for 1980 of $6.4 million.
- Took no action on a proposed budget for 1980 because several requests for major additions required further review by the Committee on Budget & Finance.
- Approved an edited version of a new statement of ACS goals, later confirmed by the Council Policy Committee.
- Authorized establishment of a task force to study the feasibility of creating a corporation to assist small chemical businesses.
- Raised the registration fee for the fall 1980 national meeting in San Francisco to $55, rescinding an earlier $50 fee.
- Approved in principle establishment of a joint task force to facilitate interaction between ACS and the American Institute of Chemical Engineers.
- Voted that ACS should offer to have an official testify orally at Congressional hearings on the 1980 budget for the Department of Agriculture's postharvest research.
- Approved distribution of $39,500 of ACS Corporation Associates dues revenues for various projects in 1980.
- Authorized creation of a special committee to plan for the establishment of an ACS Foundation for the Support of Research in Chemical Science.
- Authorized establishment of a board task force to explore ways of improving industrial/academic cooperation.
- Authorized establishment of a new, enlarged ad hoc committee to examine the possibility of creating a museum of chemistry in an ACS building, either existing or to be built.

COUNCIL

There were 490 voting members of the council in 1979, the same as in 1978. Included were 364 representing local sections, 89 from divisions, and 37 ex officio. Summaries of the two council meetings during 1979 appeared in C&EN, April 9, page 6; April 23, page 54; and Sept. 24, page 48. Five petitions up for council action at the spring meeting in Honolulu were explained in C&EN, March 19, page 57, and 13 petitions for the fall meeting in Washington were detailed in C&EN, Aug. 20, page 26.

One action affecting nearly all ACS members was a $3.00 increase in national dues for 1980 to a total of $48. This was $1.00 less than it would have been under the automatic escalator, which the council overrode after lengthy discussion of the finances of

ACS BOARD OF DIRECTORS

Chairman: William J. Bailey

Ex Officio:
Gardner W. Stacy, president
James D. D'Ianni, president-elect
Anna J. Harrison, past-president
Raymond P. Mariella (nonvoting)

Regional:
Gordon L. Nelson (I)
Patricia A. Figueras (II)
Warren D. Niederhauser (III)
Mary L. Good (IV)
Herman S. Bloch (V)
Richard M. Lemmon (VI)

Directors-at-large:
William J. Bailey
Clayton F. Callis
Pauline Newman
Robert W. Parry
Paul V. Smith Jr.
Albert C. Zettlemoyer

dues-supported activities. Another financial matter was an increase of $70 in the base allotment to local sections from ACS national funds for a total of $1060 for each section in 1980; although the councilors voted unanimously for the increase, it would have taken place automatically, and they needed to vote only if they wished a smaller increase.

Of the four petitions passed at the Honolulu meeting, the one generating the most discussion called for an addition to the ACS constitution that would formally recognize ACS international activities as an object of the society. The amendment subsequently was ratified by the ACS membership in a mail ballot.

The three other petitions approved by the council in Honolulu involved bylaw amendments (all later confirmed by the ACS Board of Directors) that concerned husband-wife dues, nomination and election procedures, and duties of certain council committees. In other action, the council declared valid a contested election for director from Region VI (C&EN, Nov. 20, 1978, page 6) in which the successful candidate won by three votes.

At the fall meeting, the council figuratively entered the electronic age when it experimented with an electronic system for the rapid tallying of votes. Although the system was used only when the outcome of a voice vote was in doubt, it was considered successful.

Ten of the 13 petitions up for council action in Washington were approved, one was defeated, and two were recommitted. All involved bylaw amendments and five also included changes in the ACS constitution. All those approved were subsequently confirmed by the ACS Board in the case of bylaw changes or ratified by the membership in the case of constitution changes, as required.

The defeated petition dealt with a proposed change in requirements for emeritus status that mainly would raise from 35 years to 40 the length of paid membership needed to qualify. The recommitted petitions were concerned with membership requirements and application procedures. The approved petitions involved the time requirement for half-dues memberships, changes in councilor representation, dues billings, local section allotments, section and division annual reports, the Committee on Professional Training, and housekeeping matters. In other actions, the council:

- Approved experiments in the fall national elections that would provide data on factors that might influence member voting response. Members were asked to indicate when they received their ballots, which had been mailed third class as usual, and half of the members in Region I got postage-paid return envelopes.
- Approved tentative plans to schedule 1985 national meetings in Miami Beach and Chicago.

TREASURER'S REPORT

The society's performance in 1979 further strengthened its sound operating and financial position. Increased revenues in generally all areas, in particular subscriptions and sales by the Chemical Abstracts Service division, and significantly increased investment revenues created a very positive effect on the society's operation and turned a budgeted deficit into a surplus of more than $2.4 million (more than $3.0 million if we include realized capital gains from investments).

Although some areas of operations moderately exceeded their expense budget, this was the result of additional production necessary to provide our favorable revenue increases. Continued close attention to cost containment in the current high-inflation economy maintained overall expenses virtually at the budgeted level.

After adjusting the net of revenues over expenses for debt retirement, depreciation, and equipment acquisitions, we will add approximately $2.9 million to the society's liquid reserve, bringing it to the $19.0 million mark. This, in turn, is about 30% of our expense budget, and thus falls within the specified guideline established by the board of directors, specifying that liquid reserves be between 25 and 30% of annual expenses.

Special mention should be made that the society's investment program contributed $4.0 million in 1979. Of this amount, $1.7 million came from investment in short-term money market instruments and $2.3 million from participation in the Investment Pool. These returns were possible because of the high interest rates that prevailed during the year and our positioning of funds to take advantage of rising rates.

John K Crum

FINANCIAL STATEMENTS FOR 1979

The Board of Directors
American Chemical Society

We have examined the balance sheet of the American Chemical Society as of Dec. 31, 1979, the related statement of revenue, expenses, and fund balances, and the related statement of expenses for the year then ended. Our examination was made in accordance with generally accepted auditing standards and, accordingly, included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances. The financial statements of the American Chemical Society for the year ended Dec. 31, 1978, totals of which are included in the accompanying financial statements for comparative purposes, were examined by other auditors, whose report, dated March 19, 1979, expressed an unqualified opinion on those statements, prior to the reclassifications described in Note 1 to the financial statements.

In our opinion, the financial statements for the year ended Dec. 31, 1979, referred to above, present fairly the financial position of the American Chemical Society as of Dec. 31, 1979, and the results of operations and changes in fund balances for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

Coopers & Lybrand

Washington, D.C.
March 3, 1980

AMERICAN CHEMICAL SOCIETY NOTES TO FINANCIAL STATEMENTS

1. SUMMARY OF ACCOUNTING POLICIES

Fund accounting—To ensure observance of limitations and restrictions placed on the use of resources available to the society, the accounts of the society are maintained in accordance with the principles of fund accounting. This is the procedure by which resources for various purposes are classified for accounting and reporting purposes into funds established according to their nature and purposes. Separate accounts are maintained for each fund; however, in the accompanying financial statements, funds that have similar characteristics have been combined into fund groups. Accordingly, all financial transactions have been recorded and reported by fund group.

Prior to 1979, the assets, liabilities, and fund balances of the society were presented in four self-balancing fund groups: general; investment pool; building, land, and equipment; and restricted. In 1979, to reflect more clearly total unrestricted funds and the ownership of the assets in the Investment Pool, the society reduced the number of fund groups to two, as follows:

Operating funds—Operating funds reflect transactions related to the general operations of the society. The society's investment in land, buildings, and capitalized equipment is also included in these funds as well as the society's participation in the Investment Pool's assets (see Note 2).

Restricted funds—Restricted funds reflect transactions of various activities that are funded by contributions, bequests, contracts, grants, and board-authorized revenue transfers. The use of these funds is restricted under the terms of the applicable agreements, wills, or authorizations.

The expenses of operating and financing the society's buildings, net of rental income of approximately $168,000 and $222,000 in 1979 and 1978, respectively, are now shown as a single caption, "net building operations." Revenue and expenses of 1978 have been reclassified to reflect this change.

Inventories—Costs of books, periodicals, and materials held for sale are charged to expense as incurred.

Property and equipment—Buildings and improvements are carried at cost and are depreciated using the straight-line method. The cost of maintenance and repairs is charged to income as incurred, whereas significant renewals and betterments are capitalized.

Purchases of furniture, fixtures, and equipment for the Washington, D.C., operations are charged directly to expense. The furniture, fixtures, and equipment for the Columbus, Ohio, buildings are carried at cost and are being depreciated over their estimated useful lives. Depreciation expense for 1979 and 1978 was $1,606,197 and $2,065,858, respectively. Gains and losses on disposal of fixed assets are recognized as miscellaneous income or expense.

Grants and contracts—Grants made by the society under the Petroleum Research Fund program are paid over a number of years and are charged to expense in the year of acceptance by the institution receiving the award. As of Dec. 31, 1979, the board of directors has approved grants in the amount of $2,114,050, which are to be offered during 1980.

The society has a number of grants from and contracts with the U.S. government which primarily provide for cost reimbursement to the society. Grant and contract revenue is recognized when the related costs are incurred by the society.

2. PARTICIPATION IN INVESTMENT POOL

The society's general reserve funds, a portion of future years' revenue collected in advance, and available restricted funds, as well as reserve funds of local sections and divisions, comprise the society's Investment Pool. The society invests funds that will be required for current operating needs separately in short-term securities. The pool follows a balanced investment policy to generate both current return and long-term appreciation. Consistent with this policy, the pool invests in marketable securities, primarily corporate bonds, notes, and stocks.

Investments are recorded at cost. Interest and dividends earned are distributed quarterly to the participating funds, based on their proportionate ownership interest. Realized capital gains and losses are allocated to the individual accounts of the participants on a quarterly basis. Gains can be withdrawn only when shares are liquidated at the time of withdrawal or partial liquidation by a participant. The pool determines gain or loss on the sale of securities by the average-cost method.

At Dec. 31, 1979, and 1978, the assets of the Investment Pool were as follows:

	1979		1978	
	Cost	**Market**	**Cost**	**Market**
Investments:				
Cash equivalents	$13,692,294	$13,692,294	$6,789,763	$6,789,763
Bonds	6,649,308	6,059,143	6,510,744	5,963,602
Stocks	—	—	5,903,788	6,483,608
	20,341,602	19,751,437	19,204,295	19,236,973
Interest receivable	212,288	212,288	152,283	152,283
Cash	(11,331)	(11,331)	55,655	55,655
	$20,542,559	$19,952,394	$19,412,233	$19,444,911

The pool had interest and dividend income of $1,802,621 and $1,467,737 in 1979 and 1978, respectively, and had a decrease in unrealized appreciation of $622,843 and $874,389 in 1979 and 1978, respectively.

3. ACCOUNTING FOR COLLECTIVE INDEXES

The society publishes the Collective Index of abstracts every five years. The current collective period began with 1977, and the Tenth Collective will be ready for printing at the end of 1981. The cost of producing the data base for this index is incurred throughout the five-year period as an integral part of producing *Chemical Abstracts*. The printing and distribution costs are incurred after the five-year period.

The society treats the Collective Index as a joint product of the abstracts production. Accordingly, costs allocated to the index during the five-year period are deferred and reflected as "Collective Indexes in process" in the balance sheet.

Proceeds from advance sales of the Tenth Collective Index, amounting to $7,783,555 as of Dec. 31, 1979, have been reflected as deferred revenue in the balance sheet.

Deferred costs and deferred revenue of the index will be recorded as operating fund expense and revenue in the years of printing and distribution, planned for 1982 and 1983, for the Tenth Collective Index. As of Dec. 31, 1979, all revenue and expenses in connection with the Ninth Collective Index have been reflected in the operating fund revenue and expenses.

4. DUES AND SUBSCRIPTIONS RECEIVED IN ADVANCE

As a result of its billing cycle, the society receives substantial amounts of dues and subscription revenue in any given year which represent payments for services to be rendered and/or publications to be delivered during the following year. At Dec. 31, 1979, revenue applicable to 1980, amounting to $20,540,394, had been received and is reflected as deferred revenue in the balance sheet.

5. LONG-TERM DEBT

The society financed the second building and the purchase of data processing equipment at Chemical Abstracts Service division in Columbus, Ohio, by the sale of two series (1971 and 1973) of Franklin County, Ohio, Industrial Development First Mortgage Revenue Bonds in the aggregate amount of $11,200,000. As a part of the financing arrangements, the society transferred to Franklin County (and leased back) a portion of its real estate and equipment having a current net book value of approximately $9,900,000. The bonds are secured by an assignment of the lease and cash and securities, which are recorded on the balance sheet at a total cost of $565,000 and have a market value of approximately $437,500 at Dec. 31, 1979. Upon payment of all outstanding bonds, the lease provides that, at the society's option, the improved property will be returned to the society for $300. In accordance with generally accepted accounting principles, the transfer has not been recognized, and the property is considered as being owned by the society.

The lease requires semiannual rental payments equal to the interest and principal payments required by the bond maturity schedule. The bonds, $9,875,000 of which have been paid as of

AMERICAN CHEMICAL SOCIETY BALANCE SHEET
DEC. 31, 1979 (WITH COMPARATIVE TOTALS FOR DEC. 31, 1978)

	1979			
	Operating funds	Restricted funds	Totals	Totals 1978
ASSETS				
Cash	$ 184,847	$ 23,736	$ 208,583	$ 273,479
Participation in Investment Pool (Note 2)				
Society funds	18,949,623	1,326,125	20,277,748	19,121,971
Affiliated organizations	—	264,811	264,811	289,904
Short-term investments, at cost which approximates market	22,573,387	6,689,200	29,262,587	23,238,440
Accounts receivable (net of allowance for doubtful accounts of $66,089 and $53,523)	1,436,706	615,020	2,051,726	1,937,519
Advances and loans to employees	81,710	—	81,710	79,333
Investment revenue receivable	330,068	159,644	489,712	550,339
Prepaid expenses	2,351,081	—	2,351,081	2,122,957
Collective Indexes in process (Note 3)	7,539,000	—	7,539,000	5,060,835
Interfund receivables (payables)	599,545	(599,545)	—	—
Property, plant, and equipment, at cost (Notes 1 and 5)				
Land	2,494,606	—	2,494,606	2,494,606
Buildings and improvements (net of accumulated depreciation of $5,470,841 and $4,997,148)	11,584,507	—	11,584,507	11,939,091
Furniture, fixtures, and equipment (net of accumulated depreciation of $8,543,874 and $7,794,519)	2,068,827	—	2,068,827	1,714,746
TOTAL ASSETS	**$70,193,907**	**$8,480,991**	**$78,674,898**	**$68,823,220**
LIABILITIES				
Accounts payable	$ 4,276,721	$ 1,377	$ 4,278,098	$ 3,515,362
Taxes and other employee withholdings	172,357	—	172,357	47,858
Estimated income taxes payable (Note 7)	267,000	—	267,000	225,000
Other payables	395,842	—	395,842	230,252
Accrued expenses:				
Salaries and related costs	1,190,431	—	1,190,431	955,027
Other	784,962	—	784,962	758,154
Grant commitments (Note 1)	—	2,951,783	2,951,783	3,014,335
Deferred revenue (Notes 3 and 4)	28,323,949	35,276	28,359,225	23,881,623
First mortgage revenue bonds payable (Note 5)	1,325,000	—	1,325,000	1,675,000
Affiliated organizations' equity in Investment Pool (Note 2)	—	264,811	264,811	289,904
TOTAL LIABILITIES	36,736,262	3,253,247	39,989,509	34,592,515
FUND BALANCES				
Operating (Note 6)				
Building, land, and equipment	14,388,012	—	14,388,012	14,302,869
General	19,069,633	—	19,069,633	16,091,301
Restricted	—	5,227,744	5,227,744	3,836,535
TOTAL FUND BALANCES	33,457,645	5,227,744	38,685,389	34,230,705
	$70,193,907	**$8,480,991**	**$78,674,898**	**$68,823,220**

The accompanying notes are an integral part of these financial statements

Dec. 31, 1979, bear interest at varying rates and are payable as follows:

Year(s)	Annual interest rate	Annual payment
1980–82	5.75%	$350,000
1983	5.75	275,000

6. OPERATING FUND BALANCE

The building, land, and equipment portion of the operating fund balance was increased by transfers from the general portion for debt amortization and capital acquisitions of $85,143 and $324,129 for 1979 and 1978, respectively. The excess of revenue over expenses for 1979 and 1978 affected the general balance only.

7. FEDERAL INCOME TAX

The society is exempt from federal income tax under section 501(c)(3) of the Internal Revenue Code and has been ruled by the Internal Revenue Service not to be a private foundation. Such organizations described in that section are taxable only on their unrelated business income.

Annual information and unrelated business income tax returns have been timely filed. Results of an IRS audit of the returns for 1968–70 have been satisfactorily settled in favor of the society.

AMERICAN CHEMICAL SOCIETY STATEMENT OF REVENUE, EXPENSES, AND FUND BALANCES FOR THE YEAR ENDED DEC. 31, 1979 (WITH COMPARATIVE TOTALS FOR YEAR ENDED DEC. 31, 1978)

	1979			
	Operating funds	Restricted funds	Totals	Totals 1978
Operating revenue:				
Dues, net of allocations to subscriptions	$ 3,448,898	$ —	$ 3,448,898	$ 3,188,616
Subscriptions	30,223,457	—	30,223,457	35,684,836
Advertising	4,614,285	—	4,614,285	3,942,008
Page charges	911,444	—	911,444	1,038,070
Sales and services	9,953,418	46,586	10,000,004	7,673,411
Interest and dividends	3,388,198	833,786	4,221,984	2,707,090
Grants and contracts	—	2,100,221	2,100,221	1,824,133
Distribution from Petroleum Research Trust Fund	—	6,782,159	6,782,159	6,159,453
Registration fees and other	1,968,710	319,666	2,288,376	1,629,062
	54,508,410	10,082,418	64,590,828	63,846,679
Expenses	52,086,774	8,717,226	60,804,000	58,924,823
Excess of operating revenue over expenses before realized capital gains	2,421,636	1,365,192	3,786,828	4,921,856
Realized capital gains	641,839	26,017	667,856	360,278
Excess of revenue over expenses	3,063,475	1,391,209	4,454,684	5,282,134
Fund balances, beginning of year	30,394,170	3,836,535	34,230,705	28,948,571
Fund balances, end of year	**$33,457,645**	**$5,227,744**	**$38,685,389**	**$34,230,705**

The accompanying notes are an integral part of these financial statements.

AMERICAN CHEMICAL SOCIETY STATEMENT OF EXPENSES FOR THE YEAR ENDED DEC. 31, 1979 (WITH COMPARATIVE TOTALS FOR YEAR ENDED DEC. 31, 1978)

	1979			
	Operating funds	Restricted funds	Totals	Totals 1978
Salaries and wages	$24,629,892	$1,064,678	$25,694,570	$23,210,265
Fringe benefits and other personnel costs	4,467,115	256,162	4,723,277	3,973,125
Professional and other personal services	2,584,802	15,922	2,600,724	2,153,897
Net building operations	2,337,204	129,366	2,466,570	2,365,572
Travel	1,540,548	61,032	1,601,580	1,290,347
Publications—production and distribution	9,646,998	10,597	9,657,595	10,046,458
Other printing and duplication	1,739,961	111,120	1,851,081	1,499,475
Promotion and circulation development	1,136,471	794	1,137,265	1,002,400
Apportionments and distributions to local sections	559,007	—	559,007	529,653
Meeting sites and event costs	453,402	6,040	459,442	382,244
Equipment costs and data processing	2,642,676	135,574	2,778,250	2,868,937
Grants, awards, and subcontracts	398,844	6,038,131	6,436,975	5,639,519
Office supplies and expenses	1,702,570	30,742	1,733,312	1,523,993
Other operating costs	1,289,041	26,476	1,315,517	1,006,873
Provision for income tax	267,000	—	267,000	225,000
Allocation of general administrative expense	(830,592)	830,592	—	—
Deferral of Tenth Collective Index expense	(2,478,165)	—	(2,478,165)	(2,324,835)
Ninth Collective Index—costs deferred from prior years	—	—	—	3,531,900
	$52,086,774	**$8,717,226**	**$60,804,000**	**$58,924,823**

The accompanying notes are an integral part of these financial statements.

After audit of the returns for the years 1971-74, IRS proposed revocation of the society's 501(c)(3) exemption on the basis that subscription price differentials between members and nonmembers constitute inurement. The IRS report also contains an alternative position in the event that the proposed revocation of exempt status is not upheld. This alternative assesses deficiencies totaling $274,560 for the four years. The society filed an appeal and protest on both these matters with IRS on April 27, 1978. A hearing on this appeal was held in August 1978, but no decision has been rendered to date. Management and legal counsel believe that ultimate resolution will be in the society's favor. Returns for years subsequent to 1974 have not been audited by IRS; however, in the opinion of management, adequate provision for income taxes on the unrelated business income has been made in the financial statements for these years.

8. PENSIONS

The society provides a defined-benefit, noncontributory pension plan, which is qualified under section 401 of the Internal Revenue Code, covering substantially all the employees of the society. The society's policy is to fully fund pension costs as accrued. The costs of the plan for 1979 and 1978 were approximately $1,917,000 and $1,667,000, respectively. The plan's actuaries have determined that the market value of the assets of the pension fund exceeded the computed value of vested benefits approximately $2,811,000 as of Nov. 1, 1979.

American Chemical Society: an 11-year statistical review

	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969
MEMBERSHIP											
Total members in good standing, Dec. 31	114,100	110,311	110,957[a]	108,744[a]	107,199[a]	105,530[a]	106,275	106,604	108,272	109,766	114,627
Unpaid members	4,114[a]	4,302[a]	4,184[a]	3,956[a]	3,621[a]	4,744[a]	4,010	4,104	3,744	4,557	2,189
Total membership	118,214[a]	116,240[a]	115,141[a]	112,730[a]	110,820[a]	110,274[a]	110,285	110,708	112,016	114,323	116,816
Membership addition during year	8,070	7,706	8,330	7,363	6,379	6,442	5,582	4,635	4,717	5,100	6,763
Membership retention	95.2%	94.9%	94.7%	94.8%	95.1%	94.3%	94.1%	94.1%	94.7%	93.7%	93.5%
Membership of divisions	48,228[b]	47,081[b]	47,425[b]	45,544[b]	45,078[b]	47,815	48,481	50,519	49,061	48,374	47,662
PUBLICATIONS											
Chemical & Engineering News											
Subscriptions[c]	128,133	125,947	124,767	123,197	121,458	120,607	121,562	125,231	129,892	132,946	136,751
Editorial pages	2,040	1,916	1,772	1,762	1,664	1,458	1,381	1,357	1,978	2,518	2,507
Analytical Chemistry											
Subscriptions	30,590	30,947	30,949	30,967	32,440	32,367	30,898	31,311	32,512	34,861	34,947
Editorial pages	3,322	3,115	3,185	3,258	3,443	3,358	3,379	3,532	2,968	2,875	2,984
Basic journals[d]											
Number of journals	12	12	12	12	12	12	12	12	12	12	12
Total subscriptions	71,032	71,751	72,305	72,514	74,487	75,126	74,018	75,571	78,655	83,193	89,567
Total editorial pages	33,060	32,888	32,690	31,713	29,872	29,871	31,366	32,445	29,806	31,052	30,881
Total papers published	6,763	6,832	6,650	6,525	6,310	6,316	6,750	6,929	6,351	6,518	6,477
Chemical Abstracts											
Documents cited	515,741	498,559	478,225	458,508	454,245	375,663	356,549	379,048	350,105	309,742	285,346
Pages	73,343[e]	68,638	68,371	65,591	62,969	54,046	51,596	54,054	50,981	48,713	44,284
ACS MEETINGS											
National[f]											
Spring: total registration	9,375	6,846	8,214	10,138	7,539	5,795	4,751	5,845	5,485	7,707[g]	6,713
Fall: total registration	9,946	6,565	7,888	9,526	6,487	6,210	7,069	7,117	8,057	8,286	11,958
Winter: total registration	—	—	—	—	3,337	—	—	—	—	—	—
Regional											
Number	9	10	8	10	6[h]	10	9	10	10	9	8
Total registration	6,524	7,789	5,934	7,280	3,675[h]	6,438	7,091	7,285	6,893	7,608	6,797
FINANCES (General Fund)											
Revenues, including realized capital gains	$55,150,249	$55,441,507	$48,087,956	$38,933,367	$33,575,790	$33,816,989	$32,357,502	$33,343,218	$29,625,920	$31,852,082	$29,065,259
Expenses, including provision for tax on unrelated business income	52,086,774	51,167,871	43,892,683	37,105,114	33,710,538	33,836,342	31,138,080	31,468,953	30,333,045	31,003,348	28,702,060
Excess of revenues over expenses	3,063,475	4,273,636	4,195,273	1,828,253	(134,748)	(19,353)	1,219,422	1,874,265	(707,125)	848,734	363,199

a Deceased members not included, as in previous years. b Paid only (comparable 1974 total was 44,797). c Excludes emeritus and life members. d Basic journals data include *Accounts of Chemical Research* (from 1968), *Biochemistry*, *Chemical Reviews*, *Inorganic Chemistry*, *Journal of Agricultural & Food Chemistry*, *Journal of the American Chemical Society*, *Journal of Chemical Information & Computer Sciences*, *Journal of Chemical & Engineering Data*, *Journal of Medicinal Chemistry*, *Macromolecules* (from 1968), *The Journal of Organic Chemistry*, *The Journal of Physical Chemistry*. e Includes estimate of pages in indexes of Vol. 91, to be published in 1980. f National meeting registrations exclude half- and one-day tickets through 1975; include one-day tickets beginning in 1976. g Two spring meetings. h Excludes Middle Atlantic symposium with 900 registrants.

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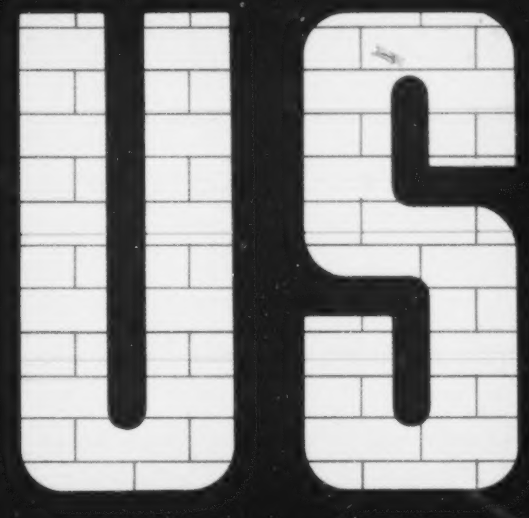
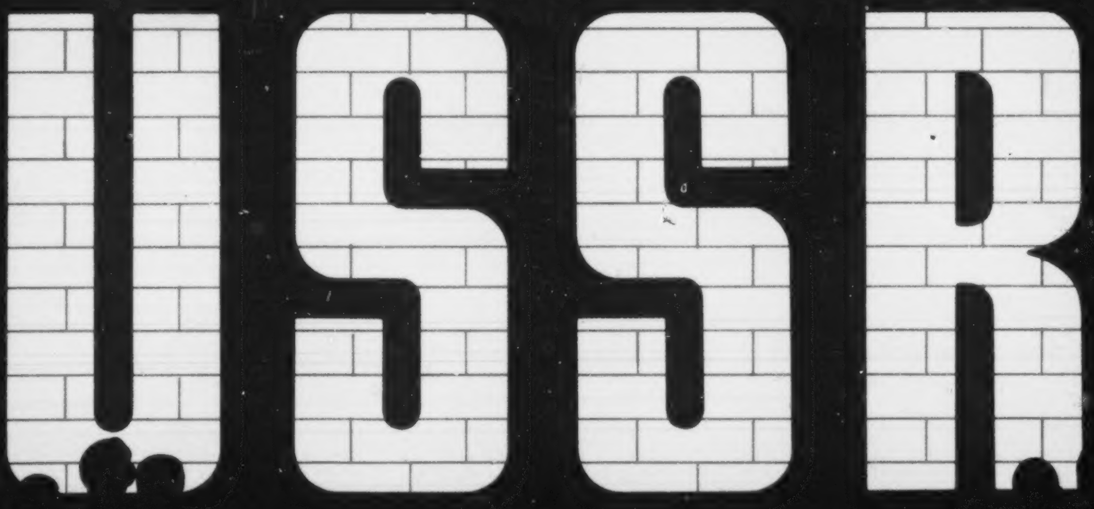
Chemical & Engineering NEWS

April 21, 1980



SCIENCE TIES VS. POWER POLITICS PAGE 37



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News of the Week

- ***Chemical prices are being squeezed*** *from two directions—White House pressure for restraint and cost increases.* ***Page 6***
- ***EPA urges U.S. chlorofluorocarbon production*** *be frozen at 1979 level to curtail depletion of stratospheric ozone.* ***Page 7***
- ***Proposed merger of OCAW*** *with two other unions would boost membership to more than 650,000.* ***Page 7***
- ***EEOC publishes guidelines*** *for evaluating complaints of sexual harassment in the workplace.* ***Page 7***
- ***Survey of pollution incidents*** *in the U.S. lists natural resource losses attributed to toxic pollution.* ***Page 8***
- ***Gene transplanted*** *into mouse bone marrow cells functions in vivo.* ***Page 8***

Business

- ***DOE demonstration project*** *may hold answer to cleanup controversy over West Valley, N.Y., nuclear waste facility.* ***Page 11***

International

- ***Essochem Europe strengthens its position*** *through purchase of LDPE operations, expansion of olefins capacity.* ***Page 14***

Government

- ***Acid rain discussion*** *at EPA-sponsored meeting yields controversy, possible EPA action under Clean Air Act.* ***Page 22***
- ***Federal R&D budget*** *will lose only $1 billion, about 3% of the original figure, if proposed cuts are made.* ***Page 23***

Science

- ***Analogs of synthetic sweetener aspartame*** *are under study to discover what determines its flavor.* ***Page 27***
- ***Norris Award winner Ronald Breslow*** *philosophizes on the attractions of physical organic chemistry.* ***Page 28***

Technology

- ***Tests of underground coal gasification*** *using technology licensed from the Soviet Union are successful.* ***Page 33***
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- ***Role of scientists*** *and scientific societies in issues involving political actions of foreign governments debated by Jeremy Stone and A. Frederick Spilhaus Jr.* ***Page 37***

ACS News

- ***Decline in Ph.D. chemist graduates halted*** *in 1979; B.S. chemist numbers stayed high; chem engineers gained markedly.* ***Page 58***
- ***Totals of graduates*** *from ACS-approved schools, other statistics are contained in 1979 annual report of Committee on Professional Training.* ***Page 60***

adopts this course of action, Goodwin sees two to four years of litigation that "will stand as an obstacle to actions that could be taken that could produce results sooner."

Not only would regulations developed under section 111d be resisted in Illinois, Goodwin says, but, "virtually any regulatory action that is proposed to mitigate acid rain is likely to be perceived as having an adverse effect on either the coal industry or electric utilities or both," and would be strongly opposed by these interests. On the other hand, northeastern states, recipients of acid rain, have clamped down on their own polluting sources and are now seeking equity in a national imposition of uniform emissions standards for all states, including coal-producing and electricity-exporting states in the Midwest and Appalachia.

Nothing was more clearly delineated at the meeting than the dichotomy between the coal-producing states and the states receiving acid rain. Until the conflicts between these two groups are resolved, the acid rain problem cannot be tackled. Both groups called for federal leadership and guidance.

EPA is certain to sidestep this role by studying its options for the next six to 12 months. Unless, of course, it is prodded into action by the momentum of bilateral treaty negotiations to get under way shortly.

As a good faith showing, EPA could enforce section 115, the international pollution abatement segment of the current law. Under this section, Canada could trigger a federal call for a revision in a bordering state's implementation plan to decrease emissions from sources within the state that are contributing to air pollution, including acid rain, in Canada.

Canada, on the receiving end of a great deal of U.S. sulfates and nitrogen oxides emissions, would like to see a bilateral air pollution treaty signed expeditiously. However, Raymond M. Robinson, the assistant deputy minister of Environment Canada, EPA's counterpart across the border, does not foresee the signing of a treaty until the U.S. reduces relevant emissions substantially.

Although Robinson tells C&EN that he sees implementation of section 111d as a promising option, the opposition he heard at the meeting from the coal-producing states made legislative changes to the Clean Air Act a probable first step toward a negotiated agreement. Because amendments to the act are not likely before 1981, an agreement with Canada on long-range air pollution is not likely before 1982.

Lois Ember, Washington

Proposed R&D budget cut amounts to only 3%

President Carter's proposed changes in his 1981 federal budget confirm earlier reports that the effects on research and development funding would be slight (C&EN, April 7, page 4).

Overall, the proposed R&D budget would be reduced slightly more than $1 billion from the originally proposed January figure, or about 2.9%. The revised 1981 budget requests $35 billion for R&D, an increase of about 11% from 1980.

The small percentage decrease was described by Frank Press, the President's science adviser and director of the Office of Science & Technology Policy, as demonstrating the Administration's philosophy that R&D is an important investment in the nation's future.

In proposing its reductions, the Administration was striving to allow some growth in existing R&D programs and to preserve a number of new programs that originally had been funded, Press says. As a result, almost all of the new initiatives would remain intact, but most would be delayed or would proceed at a slower pace.

Some of the larger projects that would be delayed include the industrial innovation initiatives program, cosponsored by the Commerce Department and the National Science Foundation; the ocean margin drilling project; and the joint government/industry cooperative automobile research program.

Funds for basic research would be

Among hardest hit in R&D budget trimming are NASA and NSF

$ Millions	Revised 1981	% change from January budget	% change from revised 1980 budget
Defense	$16,343	−1.3%	19.4%
NASA	5,398	−3.9	5.6
Energy	4,990	−2.3	2.1
NIH	3,270	−2.5	3.5
NSF	992	−6.1	10.6
USDA	778	−1.0	5.4
EPA	445	0	7.2
Interior	411	−1.0	−1.9
Commerce	371	−2.1	0
NRC	228	0	11.8
Other	1,856	−15.0	8.2
TOTAL	**$35,082**	**−2.9%**	**11.0%**

Note: Obligations. **Source:** Office of Science & Technology Policy

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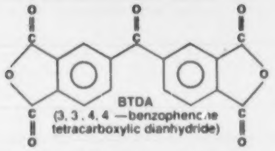

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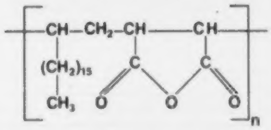

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cut slightly more than the overall R&D budget. Basic research is slated for \$4.9 billion in the revised 1981 budget, a reduction of \$194 million or about 3.8%. The reduction would permit basic research to grow 8.2% above the revised 1980 expenditures.

Programs faced with reductions have been chosen for some of the federal agencies. At the Department of Energy, for example, there would be reductions for magnetic fusion, basic energy research, and advanced coal gasification R&D. Cuts in spending also would delay construction of the ISABELLE high-energy physics project and the Solar Energy Research Institute facility. DOE's would be one of the smaller cuts in basic research with a reduction of only 1.2% to \$586 million.

At NSF, the proposed cuts would mean at least a one-year delay in the program to upgrade university research facilities. There also would be a phasedown of U.S.-U.S.S.R. cooperative research, and reduced funding for applied research projects.

The research grant program at the National Institutes of Health is slated for cuts of about \$35 million, and is not expected to hurt the Administration's plan to stabilize the number of research grant projects at NIH at about 5000.

Perhaps the agency most vulnerable to budget cuts has been the National Aeronautics & Space Administration, and it took a heavy blow in the current round of federal tightfistedness. Its R&D budget would be cut \$219 million and its basic research funding 10.5%, actually pulling basic research funds below the revised 1980 level.

Although the Administration's commitment to the space shuttle's first flight within a year still stands, a number of NASA's programs would be slowed considerably because of the cuts. These include space science, aeronautics and space technology, and tracking and data application programs. In addition, launch of the international Solar Polar mission would be pushed to 1985 from 1983 and the investment for experiments aboard Spacelab IV would be rescheduled.

Of course, the proposed 1981 budget is just that—proposed. A number of Congressional authorization committees may further cut R&D funding before they approve a budget. The motivation for these changes may be just to show a bigger surplus for 1981 or to free more funds for other areas. With both houses already working on budget revisions of their own, it is certain only that the final result is still far from clear. □

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Date: June 2–4, 1980
Site: Battelle's Columbus
Laboratories,
Columbus, Ohio
Fees: ACS members, \$375;
Nonmembers, \$425

To register or to obtain a detailed brochure on the course, call or write:
Education Dept.,
American Chemical Society,
1155 Sixteenth St., N.W.,
Washington, D.C. 20036.
202-872-4508.

Number of grads changes little

The 1978–79 academic year brought at least a temporary halt in the long and serious decline in the number of new Ph.D. chemists graduating from U.S. universities. It also brought a continuation of a high plateau in B.S. chemist graduations. And it was marked by both a further spectacular gain in the number of new B.S. chemical engineers and continuation of an equally spectacular decline in new Ph.D. chemical engineers.

These are but a few of the trends that are apparent from the masses of data contained in the latest annual report of the American Chemical Society's Committee on Professional Training. (The full text of the report starts on page 60.)

This committee (CPT) has long played a vital role in improving and monitoring undergraduate chemistry training in this country. It is the mechanism by which ACS evaluates and approves undergraduate chemistry programs. The committee does not approve either graduate chemistry programs or chemical engineering programs. However, it collects data on both areas on an annual basis and it makes periodic reports on graduate chemistry education.

Schools carrying the undergraduate chemistry program on the CPT approved list, which numbered 551 at the end of 1979, account for about 90% of all B.S. chemistry degrees awarded in the U.S. They also account for more than 90% of M.S. chemistry degrees and for essentially all chemistry Ph.D.'s.

The total number of B.S. chemistry graduates, both certified and noncertified, from CPT-approved programs seems to be set at a high level and in a pattern of modest year-to-year growth. The 1978–79 total of 10,451 was a new high and it was up 1% from the 1977–78 level. This year the same group of programs expects a total of 10,539 bachelor graduates with majors in chemistry. This will mean that graduations from CPT-approved programs will have grown at an average annual rate of 1.5% since 1975–76. In the previous four years such graduations had grown at a 5.9% average annual rate.

These schools had the most chemistry graduates, 1978–79

Total B.S. graduates		Certified B.S. graduates	
1. U of North Carolina, Chapel Hill	171	1. U of California, San Diego	74
2. Indiana U	137	2. Cornell U	61
3. U of Pittsburgh	119	2. U of Michigan, Ann Arbor	61
4. U of California, Los Angeles	111	4. Massachusetts Inst. of Technology	60
5. U of South Florida	108	5. U of Texas, Austin	56
6. U of Florida	104	6. U of Pittsburgh	52
7. U of Maryland	100	7. Rutgers U, Rutgers C	47
8. U of Miami	92	8. U of California, Berkeley	44
9. Emory U	84	9. Illinois State U	40
10. U of Illinois, Urbana	82	10. U of North Carolina, Chapel Hill	39
11. Duke U	80	10. State U of New York, Albany	39
12. Miami U	79	10. U of Washington	39
13. U of California, San Diego	74	13. U of Minnesota, Minneapolis	38
14. Auburn U	71	14. U of Delaware	35
15. U of Puerto Rico, Rio Piedras	65	14. Georgia Inst. of Technology	35
16. U of Virginia	62	16. U of California, Los Angeles	34
17. Cornell U	61	17. Rensselaer Polytechnic Inst.	32
17. U of Michigan, Ann Arbor	61	18. Brigham Young U	30
19. Massachusetts Inst. of Technology	60	18. Case Western Reserve U	30
20. California Polytechnic State U	59	18. Manhattan C	30
20. City U of New York, Brooklyn C	59	18. Rutgers U, Douglass C	30
20. U of Washington	59	22. U of Cincinnati	29
23. Northern Arizona U	57	22. Indiana U	29
23. U of Texas, Austin	56	24. U of Illinois, Chicago Circle	28
25. U of Delaware	55	24. Lehigh U	28

M.S. graduates		Ph.D. graduates	
1. U of California, San Diego	39	1. U of Illinois, Urbana	54
2. U of Illinois, Urbana	36	2. U of Wisconsin, Madison	49
2. Yale U	36	3. U of California, Berkeley	41
4. Northwestern U	29	4. Michigan State U	38
5. Columbia U	27	4. Purdue U	38
6. Ohio State U	24	6. Northwestern U	35
7. Harvard U	22	7. Cornell U	32
7. Lawrence U	22	8. U of California, Los Angeles	30
7. Purdue U	22	9. Ohio State U	29
10. Cornell U	21	10. Massachusetts Inst. of Technology	27
11. U of California, Santa Barbara	19	11. Stanford U	25
12. U of California, Berkeley	17	12. California Inst. of Technology	23
12. U of Michigan, Ann Arbor	17	12. U of Georgia	23
14. U of California, Los Angeles	16	14. Iowa State U of Sci & Tech	22
14. U of Colorado, Boulder	16	14. U of North Carolina, Chapel Hill	22
14. U of Pittsburgh	16	14. Pennsylvania State U	22
14. Wright State U	16	14. Princeton U	22
18. Stevens Institute of Technology	15	18. Columbia U	21
18. Washington U	15	18. U of Maryland	21
18. U of Washington	15	18. Texas A&M U	21
21. California State U, Long Beach	14	21. Harvard U	20
21. Eastern Michigan U	14	22. U of Chicago	18
21. St. Joseph's U	14	22. Indiana U	18
24. Pennsylvania State U	13	24. U of Florida	16
24. Rutgers U, Douglass C & Rutgers C	13	24. Howard U	16
24. Rutgers U, Newark C of Arts & Sci	13	24. U of Massachusetts	16
24. U of Southern California	13	24. U of Texas, Austin	16

Last year 42% of B.S. graduates from CPT-approved programs were certified, up from 41% for the three previous years, but still well down from the 51% level of 1968–69. Certified graduates have completed a curriculum specified by CPT. They are immediately eligible for membership in ACS and they are more likely, than are noncertified graduates, to stay in the chemical profession.

M.S. chemistry graduations showed no particular trend last year. The total of 1716 was between the totals for the two previous years and so continued the rather erratic pattern of recent years. However, Ph.D. graduates held steady at the 1532 level of 1977–78 and so brought at least a pause in the long, almost uninterrupted decline from the all-time high of 2145 in 1969–70.

The data on chemical engineering graduates in the CPT report are not complete, as chemical engineering departments are not required to report to the committee. However, the data available do reflect the sharp growth in new B.S. chemical engineers. The data also confirm that this growth will continue this year. The 112 departments that reported 4977 graduates for 1978–79 expect no less than 5854 in 1979–80. This would be more than twice the 2873 graduates reported by 120 schools in 1974–75. The data also indicate that the decline in Ph.D. graduates has been even more severe in chemical engineering than it has been in chemistry. In 1969–70 108 schools reported 430 such graduates. Last year 107 schools reported just 237.

Last year's chemical engineering data indicate that the recent surge of women into chemical engineering is starting to show up in the form of graduations. Last year women B.S. chemical engineers numbered 862, 17.3% of the class. By contrast, in 1972–73, 90 women received B.S. chemical engineering degrees, only 2.8% of the class.

As it has for the six previous years, C&EN has analyzed the CPT report to compile a ranking of the largest producers of chemistry graduates. As it did in the previous five years, the University of North Carolina, Chapel Hill, in 1978–79 produced the largest total of certified and noncertified B.S. chemists. In all, seven institutions each produced 100 or more B.S. graduates, up from five the previous year and from zero as recently as 1972–73.

For the fifth consecutive year, the University of California, San Diego, was the largest producer of certified B.S. chemists. The same school was also the largest producer of M.S. chemists, displacing Purdue University. And the University of Illinois, Urbana, was the primary producer of Ph.D. chemists for the sixth year in a row.

The rapid rise in the number of new B.S. chemical engineering graduates is reflected in the experience of Purdue University. Last year it was the largest producer with 159. It was also the largest producer in 1976–77 with just 81. The most M.S. chemical engineers, 44, last year came from Massachusetts Institute of Technology and the largest contributor to the dwindling total of Ph.D. chemical engineers was the University of California, Berkeley, with 12. □

COMMENT

Rededication to environmental progress

Tomorrow, April 22, is Earth Day 1980, marking the beginning of our second environmental decade. It is my sincere hope that members of ACS, on this occasion, will rededicate themselves to achieving another decade of environmental progress.

I was especially pleased to note that among the goals President Carter stated in his Earth Day 1980 proclamation was that the people of this planet be freed from the spread of toxic chemicals. Much public concern has been expressed recently about this and other problems involving chemicals.

Admittedly, there is cause for concern over problems related to chemicals. No technology is without its risks and dangers. Yet, the concerns over chemical problems and the environment are of long standing to ACS and its members. The society has a record of concern and action regarding environmental improvement of which it can be proud.

In 1967 the society inaugurated its monthly publication *Environmental Science & Technology* as an instrument for reports on aspects of the environment and its control by scientific, engineering, and political means. This magazine is read monthly by more than 18,000 people.

To further demonstrate its commitment to enhancing the quality of life, the society in 1979 established its Committee on Environmental Improvement. From this committee has come "Cleaning Our Environment," a massive study of environmental problems and recommended solutions first published in 1969. An updated and expanded edition was published in 1978. These studies offer a considerable number of recommendations on controlling nuclear and other hazardous wastes, pesticide use, control of air and water pollution, toxicology, and the importance and use of chemical analysis in environmental protection. It is unfortunate that many of our recommendations have not been pursued as vigorously as environmental conditions demand.

In 1973 one of the society's divisions, long concerned with the problems of pollution, evolved into the Division of Environmental Chemistry. Work in its area has expanded dramatically, and literally hundreds of research papers on environmental problems and their solutions are presented through the division at the society's two national meetings each year.

The decade just past also saw enactment of much needed environmental legislation. Since 1973, through testimony before Congress and in numerous other public statements, ACS has strongly supported the concept of toxic substances control. With passage of the Toxic Substances Control Act in 1976, the society began working with the Environmental Protection Agency to develop regulations implementing the act. The society is pledged to do all it can to ensure that EPA's regulations have a strong scientific foundation and are credible to both the scientific community and the general public.

Chemical science has helped make life better, but with some consequences and costs that we are only now beginning to learn. In this light, chemistry has made some of the most agonizing choices necessary, and it has also made some of the most promising choices possible.

Like other scientists, chemists cannot always know the future implications of what they learn and do. The opportunities for benefiting society are infinite. I hope you will join me in pledging that this is what we intend to do—benefit society while minimizing any possible damage to our environment.

James D. D'Ianni
ACS president

ACS Committee on Professional Training, 1979 Annual Report

Summary of data from approved programs, 1975–79

	Bachelors				Masters		Doctorates	
	Number of schools	Graduates (total)	Certified graduates	Non-certified graduates	Number of schools	Graduates	Number of schools	Graduates
CHEMISTRY								
1975	526	9,084	3897	5187	319	1814	189	1781
1976	528	9,916	4103	5813	322	1676	189	1622
1977	534	10,207	4219	5988	321	1688	189	1563
1978	547	10,350	4285	6065	323	1798	189	1532
1979	551	10,451	4424	6027	323	1716	188	1532
CHEMICAL ENGINEERING[a]								
1975	120	—	2873	—	117	1012	105	351
1976	120	—	2920	—	108	1001	101	320
1977	120	—	3282	—	115	1095	103	298
1978	119	—	4225	—	114	1109	98	251
1979	112	—	4977	—	107	951	92	237

[a] Chemical engineering departments are not required to report their data to CPT, so the number of departments included in this category varies from year to year. **Note:** Bachelor's degree projections for 1980: 551 chemistry departments report that they expect a total of 10,539 bachelor graduates with majors in chemistry during the 1979–80 academic year, and 112 chemical engineering departments report that they expect a total of 5854 bachelor graduates with majors in chemical engineering.

The number of baccalaureate graduates in chemistry from schools whose undergraduate chemistry programs are approved by ACS rose 1% in 1978–79 from the previous year. The number of master's degrees from these departments decreased 5% from 1978, and the number of Ph.D. degrees was the same as 1977–78.

The percentage of baccalaureate graduates certified to ACS rose to 42%, up slightly from the 41% reported for the previous three years. (Certified graduates are those who have completed the curriculum specified by CPT and are eligible for full membership in ACS; noncertified graduates may become associate members of ACS upon graduation and full members after three years of professional experience or a higher degree in a chemical science.)

Total numbers of bachelor's degrees (certified and noncertified), master's degrees, and Ph.D. degrees awarded in 1978–79 by departments whose chemistry programs are ACS-approved are listed by institution in the large table at the end of this report and are summarized in the two smaller tables. These tables also include numbers of chemical engineering graduates from institutions whose programs are accredited by the American Institute of Chemical Engineers and the Engineers Council for Professional Development. (Note: These departments are not required to report their data to CPT, so the number of departments included in this listing varies from year to year.)

It is interesting to note that the number of bachelor's degrees in chemical engineering from the 112 AIChE-ECPD-accredited departments that reported in 1979 increased 18% from the total reported by 119 departments the previous year and that these 112 departments reported an expected further increase of 18% in 1980. Over the five-year period from 1975 to 1979, the number of reported bachelor's degree graduates in chemical engineering from these schools has increased 73%. At the graduate level, the number of chemical engineering master's degrees reported in 1979 decreased 14% from the year before, and the number of Ph.D. degrees reported continued to decline, down 6% from 1978.

As part of the committee's approval activities, programs at all ACS-approved departments are normally re-evaluated at five-year intervals. There were 553 colleges and universities on the approved list at the end of 1979, and the committee studied the chemistry programs at 153 of them during the year. Each involved a review of extensive documentary materials submitted by the department head describing the current status of the program. During 1979, six chemistry programs were newly approved by the committee, two approved programs were put on probation, three were continued on probation, and two were removed from probation. No departments were removed from the approved list.

The 1979 edition of the Directory of Graduate Research, a listing of Ph.D.-degree-granting departments of chemistry, chemical engineering, biochemistry, and pharmaceutical/medicinal chemistry in the U.S. and Canada, was published in October. Production was again handled through a computerized process utilizing the data bank and computer facilities of Chemical Abstracts Service. The amount of information included in this edition of the directory, a biennial publication, again increased about 11%, as it had for the previous two editions, although the number of departments included (528) increased only 1.5% from the previous edition. Copies of the 1979 edition are available from ACS for $30 each.

The committee is involved in a study of the feasibility of preparing a concordance of faculty research interests by using the data in the Directory of Graduate Research. In addition to a printed version of the concordance, the committee also is looking into the possibility of constructing a tape of these data that would be available through on-line access to computer-readable files.

In response to a request from the ACS Division of Analytical Chemistry, the committee revised its section on analytical chemistry requirements in the 1977 revision of the criteria for ACS-approved programs. It was the feeling of the committee that the omission of the material was an oversight in the wording and that the addition represented no substantive change in CPT's actual practice.

Two members of the AIChE Education & Accreditation Committee

Summary of totals from 1979 reports from approved programs

	Schools reporting	Men	Women	Total
CHEMISTRY				
Bachelors, total	551	7652	2789	10,451
Certified		3317	1107	4,424
Noncertified		4336	1691	6,027
Masters	323	1268	448	1,716
Doctorates	188	1289	243	1,532
CHEMICAL ENGINEERING				
Bachelors, certified	112	4115	862	4,977
Masters	107	879	72	951
Doctorates	92	233	4	237

Committee members, 1979

H. S. Mosher, *chairman*

J. A. Campbell	H. A. Laitinen
E. L. Eliel	J. H. Lunsford
P. A. Figueras	P. G. Lykos
H. B. Gray	E. M. Pearce
D. E. Jones	M. B. Robin
	J. P. Segrest

B. R. Blaser, *secretary*

(CPT's counterpart in AIChE) met with the committee to discuss the concerns of AIChE in regard to the lessening amount of chemistry in the chemical engineering curriculum and the lack of industrial chemistry and chemical engineering in the chemistry curriculum. It was suggested that a joint AIChE-ACS group be set up to define the advanced chemistry subjects essential to chemical engineering and also those important for chemists entering industry. As a result of a recommendation by CPT to the ACS experimental Education Commission, three ACS representatives have been appointed to this joint task force.

The ACS Council at its September meeting voted in favor of amending the ACS bylaws to include a definition of CPT's accrediting function for ACS. As reported previously, the Council on Postsecondary Accreditation (COPA), the national nonprofit organization whose major purpose is to support, coordinate, and improve all nongovernment accrediting at the postsecondary level in the U.S., had specified that CPT, in order to continue to be recognized by COPA, show an improved status in ACS's corporate structure. The committee agreed to document for COPA its recognition process for program approval (in lieu of accreditation) to serve as a model for organizations that desire recognition of less elaborate and costly methods of evaluating programs in their fields.

The terms of J. Arthur Campbell, Edward S. Lewis, Harry B. Gray, and Melvin B. Robin expired at the end of 1978. Campbell, Gray, and Robin were reappointed for three-year terms. Ernest M. Eliel and Herbert A. Laitinen received new appointments.

Chemical and chemical engineering degrees awarded by approved schools, 1978–79

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelors, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Abilene Christian U	4	3	2	—	—	—	—
Adelphi U	2	7	0	4	—	—	—
Agnes Scott C	2	0	—	—	—	—	—
Akron, U of	17	0	3	3	25	2	2
Alabama, U of							
University	5	30	2	3	26	8	0
Birmingham	3	14	1	2	—	—	—
Huntsville	2	5	1	—	—	—	—
Alaska, U of	4	0	1	—	—	—	—
Albion C	7	10	—	—	—	—	—
Albright C	6	20	—	—	—	—	—
Alfred U	6	0	—	—	—	—	—
Allegheny C	3	30	—	—	—	—	—
Alma C	1	10	—	—	—	—	—
American U	7	3	3	3	—	—	
Amherst C	1	2	—	0	—	—	—
Andrews U	5	6	—	—	—	—	—
Antioch C	6	2	—	—	—	—	—
Appalachian State U[a]	1	5	0	—	—	—	—
Arizona State U	27	17	3	9	27	4	0
Arizona, U of	27	20	2	13	34	4	0
Arkansas, U of							
Fayetteville	6	19	3	7	31	4	0
Little Rock	10	6	1	—	—	—	—
Ashland C	2	2	—	—	—	—	—
Auburn U	9	62	5	3	46	7	1
Augsburg C	3	9	—	—	—	—	—
Augustana C, Rock Island, Ill.	3	14	—	—	—	—	—
Augustana C, Sioux Falls, S.D.	2	9	—	—	—	—	—
Austin C	0	9	—	—	—	—	—
Baldwin-Wallace C	2	5	—	—	—	—	—
Ball State U	6	2	5	—	—	—	—
Barnard C	0	21	—	—	—	—	—
Bates C	5	9	—	—	—	—	—
Baylor U	15	14	3	5	—	—	—
Beloit C	0	10	—	—	—	—	—
Bemidji State U	3	1	—	—	—	—	—
Birmingham-Southern C	3	15	—	—	—	—	—
Bloomsburg State C	4	2	—	—	—	—	—
Boston C	13	13	5	1	—	—	—
Boston U	7	20	7	6	—	—	—
Bowdoin C	0	31	—	—	—	—	—
Bowling Green State U	6	28	4	—	—	—	—
Bradley U	3	5	0	—	—	—	—
Brandeis U	1	17	6	9	—	—	—
Bridgeport, U of	6	0	4	—	—	—	—
Bridgewater State C	5	4	3	—	—	—	—
Brigham Young U	30	9	4	4	32	2	2
Brown U	2	37	1	14	—	—	—
Bryn Mawr C	11	0	0	3	—	—	—
Bucknell U	18	10	4	—	25	5	—
Butler U	4	12	3	—	—	—	—
California Institute of Tech	22	0	5	23	12	5	8
California Polytechnic State U	20	39	1	—	—	—	—
California State C	—	—	—				
Bakersfield	6	1	—	—	—	—	—
San Bernardino	1	7	—	—	—	—	—
Stanislaus	3	1	—	—	—	—	—
California State Polytechnic U	11	0	4	—	(e)	—	—
California State U							
Chico	4	7	—	—	—	—	—
Dominguez Hills	4	3	—	—	—	—	—
Fresno	4	9	5	—	—	—	—
Fullerton	14	12	1	—	—	—	—
Hayward	16	29	2	—	—	—	—
Long Beach	10	26	14	—	—	—	—
Los Angeles	14	0	1	—	—	—	—
Northridge	5	10	1	—	—	—	—
Sacramento	7	4	4	—	—	—	—
California, U of							
Berkeley	44	0	17	41	92	33	12
Davis	10	7	3	14	50	1	0
Irvine	6	44	6	9	—	—	—
Los Angeles	34	77	16	30	—	—	—
Riverside	16	1	12	6	—	—	—
San Diego	74	0	39	13	—	—	—
Santa Barbara	23	0	19	10	28	5	0
Santa Cruz	18	1	5	10	—	—	—
Calvin C	6	41	—	—	—	—	—
Canisius C	0	5	—	—	—	—	—
Capital U	1	5	—	—	—	—	—
Carleton C	4	28	—	—	—	—	—
Carnegie-Mellon U	24	1	4	5	(e)	—	—
Carroll C	2	9	—	—	—	—	—
Carthage C	2	6	—	—	—	—	—
Case Western Reserve U	30	7	1	8	25	12	1
Catholic U of America	8	1	2	3	8	3	1
Centenary C of Louisiana	0	5	—	—	—	—	—
Central C	0	5	—	—	—	—	—
Central Connecticut State C	9	3	3	—	—	—	—
Central Florida, U of	12	0	4	—	—	—	—
Central Michigan U	5	11	7	—	—	—	—
Central State U	4	2	—	—	—	—	—
Charleston, C of[a]							
Chatham C	2	0	—	—	—	—	—
Chicago, U of	7	22	11	18	—	—	—
Cincinnati, U of	29	0	8	10	48	15	1
Citadel, The	1	14	—	—	—	—	—
City U of New York	—	—	—	11	—	—	—
Brooklyn C	5	54	6	—	—	—	—
City C	1	17	1	—	30	4	1
Herbert H. Lehman C	11	0	—	—	—	—	—
Hunter C	7	14	1	—	—	—	—
Queens C	15	21	3	—	—	—	—
Clarion State C	6	2	—	—	—	—	—
Clark U	14	0	4	2	—	—	—
Clarkson C of Technology	19	0	11	2	(e)	—	—
Clemson U	11	2	2	3	36	2	1
Cleveland State U	23	0	11	3	71	17	—
Coe C	1	4	—	—	—	—	—
Colby C	1	6	—	—	—	—	—
Colgate U	0	20	—	—	—	—	—
Colorado C	6	5	—	—	—	—	—
Colorado School of Mines & Technology	4	0	7	2	50	7	6
Colorado State U	9	12	4	13	—	—	—
Colorado, U of							
Boulder	26	22	16	12	46	9	1

Continued on page 66

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelors, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Denver	2	16	3	—	—	—	—
Columbia U	10	0	27	21	59	26	2
Concordia C	5	7	—	—	—	—	—
Connecticut, U of	21	21	6	6	52	5	1
Cooper Union[b]					(e)	—	—
Cornell C	0	11	—	—	—	—	—
Cornell U	61	0	21	32	74	12	3
Dartmouth C	0	35	1	2	—	—	—
David Lipscomb C	3	24	—	—	—	—	—
Davidson C	10	4	—	—	—	—	—
Dayton, U of	10	9	4	—	39	0	—
Delaware State C	1	5	—	—	—	—	—
Delaware, U of	35	20	3	4	61	19	7
Delaware Valley C of Science & Agriculture	4	0	—	—	—	—	—
Denison U	2	14	—	—	—	—	—
Denver, U of	3	5	5	0	—	—	—
De Paul U	0	8	6	—	—	—	—
DePauw U	2	12	0	—	—	—	—
Detroit, U of	8	4	2	3	(e)	—	—
Dickinson C	1	11	—	—	—	—	—
Drake U	2	3	0	—	—	—	—
Drew U	2	6	—	—	—	—	—
Drexel U	13	2	9	1	42	5	0
Duke U	14	66	2	14	—	—	—
Duquesne U	5	3	9	0	—	—	—
Earlham C	1	6	—	—	—	—	—
East Carolina U	5	8	2	—	—	—	—
East Stroudsburg State C	3	14	—	—	—	—	—
East Tennessee State U	4	2	2	—	—	—	—
East Texas State U	3	9	8	—	—	—	—
Eastern Illinois U	12	2	3	—	—	—	—
Eastern Kentucky U	1	7	1	—	—	—	—
Eastern Michigan U	7	25	14	—	—	—	—
Elizabethtown C	4	21	—	—	—	—	—
Elmhurst C	1	7	—	—	—	—	—
Emmanuel C	0	3	—	—	—	—	—
Emory U	5	79	12	4	—	—	—
Emporia State U	2	8	3	—	—	—	—
Evansville, U of	2	9	—	—	—	—	—
Fairfield U	11	6	—	—	—	—	—
Fairleigh Dickinson U							
Rutherford	4	0	7	—	—	—	—
Teaneck	27	0	4	—	—	—	—
Fisk U	9	0	3	—	—	—	—
Florida Atlantic U	9	20	0	—	—	—	—
Florida State U	2	36	4	13	—	—	—
Florida, U of	5	99	4	16	51	18	5
Fordham U	5	9	10	6	—	—	—
Franklin and Marshall C	14	17	—	—	—	—	—
Furman U	2	14	1	—	—	—	—
Geneva C	3	8	—	—	—	—	—
George Mason U	7	2	—	—	—	—	—
George Washington U	4	15	1	1	—	—	—
Georgetown U	25	0	10	7	—	—	—
Georgia Institute of Technology	35	0	8	10	132	7	0
Georgia State U	2	8	3	—	—	—	—
Georgia, U of	4	41	6	23	—	—	—
Gettysburg C	2	7	—	—	—	—	—
Gonzaga U	2	6	—	—	—	—	—
Goucher C	4	5	—	—	—	—	—
Grand Valley State C	3	9	—	—	—	—	—
Grinnell C	7	18	—	—	—	—	—
Gustavus Adolphus C	10	11	—	—	—	—	—
Hamilton C	0	7	—	—	—	—	—
Hamline U	5	3	—	—	—	—	—
Hampden-Sydney C	5	5	—	—	—	—	—
Hampton Institute	0	1	—	—	—	—	—
Hartford, U of	5	2	0	—	—	—	—
Hartwick C	3	3	—	—	—	—	—
Harvard U	—	25	22	20	—	—	—
Harvey Mudd C	10	0	—	—	—	—	—
Haverford C	12	6	—	—	—	—	—
Hawaii, U of	10	5	5	4	—	—	—
Hiram C	1	5	—	—	—	—	—
Hobart and William Smith C	6	13	—	—	—	—	—
Hofstra U	1	12	—	—	—	—	—
Hollins C	1	1	—	—	—	—	—
Holy Cross, C of The	3	43	1	—	—	—	—
Hope C	14	16	—	—	—	—	—
Houston, U of	10	1	7	13	27	10	4
Howard U	4	33	2	16	20	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelors, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Humboldt State U	4	7	—	—	—	—	—
Idaho State U	0	4	1	—	—	—	—
Idaho, U of	6	4	5	1	14	12	1
Illinois Benedictine C	21	0	—	—	—	—	—
Illinois Institute of Technology	16	0	2	2	41	17	6
Illinois State U	40	0	7	—	—	—	—
Illinois, U of							
Chicago Circle	28	26	12	7	27	7	1
Urbana-Champaign	18	64	36	54	102	13	9
Illinois Wesleyan U	0	7	—	—	—	—	—
Indiana State U	2	6	0	—	—	—	—
Indiana U	29	108	7	18	—	—	—
Indiana U of Pennsylvania	14	7	2	—	—	—	—
Indiana U, South Bend[a]	2	5	—	—	—	—	—
Indiana U-Purdue U							
Fort Wayne	3	2	—	—	—	—	—
Indianapolis	3	19	4	—	—	—	—
Iowa State U of Science & Technology	12	5	11	22	71	12	5
Iowa, U of	7	2	12	9	22	2	1
Ithaca C	3	4	—	—	—	—	—
Jackson State U	8	0	1	—	—	—	—
John Carroll U	12	23	3	—	—	—	—
Johns Hopkins U	10	1	9	7	—	—	—
Juniata C	7	9	—	—	—	—	—
Kalamazoo C	7	18	—	—	—	—	—
Kansas State U	5	2	6	3	25	5	1
Kansas, U of	16	22	7	7	53	3	0
Kearney State C	0	5	—	—	—	—	—
Kent State U	8	10	2	4	—	—	—
Kentucky, U of	8	6	11	1	34	7	2
Kenyon C	7	0	—	—	—	—	—
King's C	5	0	—	—	—	—	—
Knox C	3	20	—	—	—	—	—
Lafayette C	5	10	—	—	23	—	—
Lake Forest C	1	11	—	—	—	—	—
Lamar U	10	3	1	—	27	4	1
LaSalle C	6	3	—	—	—	—	—
Lawrence U	9	3	22	12	—	—	—
Lebanon Valley C	9	2	—	—	—	—	—
Lehigh U	28	0	8	9	90	22	9
Le Moyne C	10	0	—	—	—	—	—
Lincoln U	0	3	—	—	—	—	—
Long Island U							
Brooklyn Center—Conolly C	3	5	7	—	—	—	—
C. W. Post C	8	1	—	—	—	—	—
Loras C	2	5	—	—	—	—	—
Louisiana State U							
Baton Rouge	6	12	5	5	50	5	2
Shreveport[a]							
Louisiana Tech U	1	3	1	—	15	5	—
Louisville, U of	4	20	6	2	—	20	1
Lowell, U of	20	2	10	2	40	2	—
Loyola C	3	1	—	—	—	—	—
Loyola Marymount U	12	0	—	—	—	—	—
Loyola U	0	1	—	—	—	—	—
Loyola U of Chicago	10	14	2	3	—	—	—
Luther C	3	9	—	—	—	—	—
Macalester C	3	13	—	—	—	—	—
MacMurray C	3	0	—	—	—	—	—
Maine, U of	2	3	5	1	31	4	0
Manhattan C[c]	30	3	—	—	44	27	—
Manhattanville C	3	2	—	—	—	—	—
Mankato State U	3	9	0	—	—	—	—
Marietta C	8	2	—	—	—	—	—
Marist C	0	3	—	—	—	—	—
Marquette U	19	0	3	3	—	—	—
Marshall U	8	16	5	—	—	—	—
Maryland, U of	9	91	11	21	51	15	3
Maryland Baltimore County	17	0	2	0	—	—	—
Massachusetts Institute of Technology	60	0	7	27	86	44	8
Massachusetts, U of	14	2	10	16	51	4	7
McMurry C	2	2	—	—	—	—	—
McNeese State U	2	6	0	—	—	—	—
Memphis State U	6	8	0	0	—	—	—
Merrimack C	8	0	—	—	—	—	—
Metropolitan State C	9	5	—	—	—	—	—
Miami U	19	60	5	3	—	—	—
Miami, U of	2	90	2	5	—	—	—
Michigan State U	16	11	10	38	72	8	0

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelors, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Michigan Technological U	12	1	2	0	69	5	—
Michigan, U of							
Ann Arbor	61	0	17	12	109	28	4
Dearborn	13	6	—	—	—	—	—
Flint	1	9	—	—	—	—	—
Middle Tennessee State U	0	41	1	—	—	—	—
Middlebury C	0	13	0	—	—	—	—
Midwestern State U	6	1	—	—	—	—	—
Millersville State C	7	2	—	—	—	—	—
Millsaps C	3	22	—	—	—	—	—
Minnesota, U of							
Minneapolis	38	0	7	12	(e)	—	—
Duluth	11	5	2	—	—	—	—
Mississippi C	0	11	—	—	—	—	—
Mississippi State U	7	9	0	0	23	1	0
Mississippi, U of	2	21	0	0	14	1	0
Missouri, U of							
Columbia	17	18	12	2	62	4	2
Kansas City	11	16	3	3	—	—	—
Rolla	10	0	6	6	88	4	3
St. Louis	10	9	5	1	—	—	—
Monmouth C	0	4	—	—	—	—	—
Montana State U	6	0	3	2	47	4	2
Montana, U of	3	6	2	0	—	—	—
Montclair State C	9	27	5	—	—	—	—
Moorhead State U	4	2	0	—	—	—	—
Moravian C	3	5	—	—	—	—	—
Morehouse C[d]	6	4	12	—	—	—	—
Morgan State U	3	6	—	—	—	—	—
Mount Holyoke C	0	11	0	0	—	—	—
Mount Saint Vincent, C of[c]	3	0	—	—	—	—	—
Muhlenberg C	4	12	—	—	—	—	—
Murray State U	7	16	5	—	—	—	—
Muskingum C	2	6	—	—	—	—	—
Nebraska, U of							
Lincoln	9	9	9	15	14	4	—
Omaha	4	7	—	—	—	—	—
Nebraska Wesleyan U	5	7	—	—	—	—	—
Nevada, U of							
Las Vegas	4	0	—	—	—	—	—
Reno	3	3	2	1	—	—	—
New Hampshire, U of	2	6	2	1	15	1	0
New Jersey Institute of Tech[b]	—	—	—	—	102	17	0
New Mexico Highlands U	0	2	2	—	—	—	—
New Mexico Institute of Mining & Technology	8	0	4	—	—	—	—
New Mexico State U	6	9	10	3	27	4	—
New Mexico, U of	11	11	7	10	27	4	1
New Orleans, U of	5	6	2	5	—	—	—
New York U	8	23	12	3	—	—	—
North Alabama, U of	11	11	—	—	—	—	—
North Carolina A&T State U	1	0	2	—	—	—	—
North Carolina Central U	0	9	1	—	—	—	—
North Carolina State U	24	5	4	3	53	10	4
North Carolina, U of							
Chapel Hill	39	132	5	22	—	—	—
Charlotte	4	9	1	—	—	—	—
Greensboro	13	5	1	—	—	—	—
Wilmington	6	11	—	—	—	—	—
North Dakota State U	7	2	3	6	—	—	—
North Dakota, U of	3	8	2	1	17	5	—
North Texas State U	5	10	2	1	—	—	—
Northeast Louisiana U	5	0	5	—	—	—	—
Northeastern U	6	0	6	7	(e)	—	—
Northern Arizona U	10	47	0	—	—	—	—
Northern Colorado, U of	5	5	0	—	—	—	—
Northern Illinois U	19	17	3	3	—	—	—
Northern Iowa, U of	2	4	2	—	—	—	—
Northern Michigan U	1	11	1	—	—	—	—
Northwest Missouri State U	2	1	—	—	—	—	—
Northwestern State U of Louisiana	1	2	0	—	—	—	—
Northwestern U	11	18	29	35	52	15	6
Norwich U	0	0	—	—	—	—	—
Notre Dame, U of	6	18	4	3	51	4	5
Oakland U	17	8	2	—	—	—	—
Oberlin C	0	31	0	—	—	—	—
Occidental C	2	18	—	—	—	—	—
Ohio Northern U	3	2	—	—	—	—	—
Ohio State U	11	3	24	29	63	6	2
Ohio U	8	9	1	7	21	2	1
Ohio Wesleyan U	3	5	—	—	—	—	—
Oklahoma State U	3	4	3	8	47	22	3
Oklahoma, U of	12	18	12	2	50	6	7
Old Dominion U	5	10	7	—	—	—	—
Oregon State U	12	0	6	5	43	9	2
Oregon, U of	8	6	11	7	—	—	—
Pace U	3	1	—	—	—	—	—
Pacific Lutheran U	4	12	—	—	—	—	—
Pacific, U of the	3	12	3	0	—	—	—
Pennsylvania State U	9	13	13	22	112	14	7
Pennsylvania, U of	11	12	4	12	36	13	6
Philadelphia C of Pharmacy & Science	3	0	2	0	—	—	—
Philadelphia C of Textiles & Science	4	0	—	—	—	—	—
Pittsburg State U	3	0	4	—	—	—	—
Pittsburgh, U of	52	67	16	13	68	13	2
Polytechnic Institute of New York	7	0	7	8	31	5	2
Pomona C	5	7	—	—	—	—	—
Portland State U	9	7	3	—	—	—	—
Pratt Institute[b]	—	—	—	—	8	—	—
Princeton U	13	8	10	22	(e)	—	—
Providence C	6	9	1	1	—	—	—
Puerto Rico, U of							
Mayaguez	18	10	6	—	89	0	—
Rio Piedras	10	55	3	3	—	—	—
Puget Sound, U of	9	11	2	—	—	—	—
Purdue U	25	16	22	38	159	10	2
Purdue U, Calumet	8	0	—	—	—	—	—
Randolph Macon Woman's C	0	2	—	—	—	—	—
Redlands, U of	0	3	—	—	—	—	—
Reed C	16	4	—	—	—	—	—
Regis C	3	5	—	—	—	—	—
Rensselaer Polytechnic Institute	32	0	7	7	97	10	2
Rhode Island, U of	6	2	4	3	23	3	0
Rice U	6	4	2	10	—	19	5
Richmond, U of	2	13	0	—	—	—	—
Rider C	4	0	—	—	—	—	—
Ripon C	5	0	—	—	—	—	—
Roanoke C	1	3	—	—	—	—	—
Rochester Institute of Tech	5	7	7	—	—	—	—
Rochester, U of	16	13	10	13	25	9	3
Rollins C	1	3	—	—	—	—	—
Roosevelt U	7	3	7	—	—	—	—
Rose-Hulman Institute of Technology	4	0	—	—	(e)	—	—
Russell Sage C	6	2	—	—	—	—	—
Rutgers U	—	—	—	—	(e)	—	—
Douglass C	30	0	13	11	—	—	—
Rutgers C	47	0					
Newark C of Arts & Sciences	17	11	13	3	—	—	—
Saginaw Valley State C	2	8	—	—	—	—	—
St. Anselm's C	2	5	—	—	—	—	—
St. Cloud State U	3	10	—	—	—	—	—
St. John Fisher C	10	1	—	—	—	—	—
St. John's U	9	1	7	2	—	—	—
St. Joseph C	2	2	6	—	—	—	—
St. Joseph's U	5	23	14	—	—	—	—
St. Lawrence U	12	21	—	—	—	—	—
St. Louis U	6	35	4	2	—	—	—
St. Mary's C[a]	0	10	—	—	—	—	—
St. Olaf C	10	32	—	—	—	—	—
St. Peter's C	0	1	—	—	—	—	—
St. Thomas, C of	3	11	—	—	—	—	—
Sam Houston State U	9	3	3	—	—	—	—
San Diego State U	25	0	6	0	—	—	—
San Francisco State U	18	30	4	—	—	—	—
San Francisco, U of	8	3	2	—	—	—	—
San Jose State U	21	19	8	—	18	7	—
Santa Clara, U of	10	10	—	—	—	—	—
Scranton, U of	20	17	9	—	—	—	—
Seattle U	1	3	—	—	—	—	—
Seton Hall U	9	7	9	2	—	—	—
Shippensburg State C	8	4	3	—	—	—	—
Siena C	9	0	—	—	—	—	—
Simmons C	3	4	—	—	—	—	—
Skidmore C	2	13	—	—	—	—	—
Slippery Rock State C	3	1	—	—	—	—	—
Smith C	2	5	1	0	—	—	—
Sonoma State C	0	10	—	—	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelors, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
South Carolina, U of	9	22	7	13	21	3	1
South Dakota School of Mines & Technology	2	1	8	—	20	1	—
South Dakota State U	3	19	3	—	—	—	—
South Dakota, U of	7	23	6	—	—	—	—
South Florida, U of	23	85	1	3	16	2	0
Southeast Missouri State U	0	1	—	—	—	—	—
Southeastern Massachusetts U	3	8	2	—	—	—	—
Southern California, U of	10	5	13	6	(e)	—	—
Southern Illinois U							
Carbondale	3	15	1	7	—	—	—
Edwardsville	3	13	6	—	—	—	—
Southern Methodist U	7	11	1	—	—	—	—
Southern Mississippi, U of	3	8	5	1	—	—	—
Southern Oregon State C	2	0	—	—	—	—	—
Southern U & A&M C	3	0	1	—	—	—	—
Southwest Missouri State U	1	17	—	—	—	—	—
Southwest State U	2	3	—	—	—	—	—
Southwest Texas State U	12	2	4	—	—	—	—
Southwestern at Memphis	3	2	—	—	—	—	—
Southwestern Louisiana, U of	4	13	0	—	16	—	—
Southwestern Oklahoma State U	7	14	—	—	—	—	—
Stanford U	18	6	2	25	19	18	6
State U of New York							
Albany	39	0	2	3	—	—	—
Binghamton	0	43	4	4	—	—	—
Buffalo	16	27	8	13	55	7	1
Stony Brook	23	7	8	15	—	—	—
C at Brockport	2	11	—	—	—	—	—
C at Buffalo	9	9	0	—	—	—	—
C at Cortland	8	9	—	—	—	—	—
C at Fredonia	13	1	0	—	—	—	—
C at Geneseo	3	5	1	—	—	—	—
C at New Paltz	7	0	2	—	—	—	—
C at Oneonta	3	20	0	—	—	—	—
C at Oswego	20	8	4	—	—	—	—
C at Plattsburgh	3	11	0	—	—	—	—
C at Potsdam	4	22	—	—	—	—	—
Stephen F. Austin State U	3	4	2	—	—	—	—
Stetson U	3	2	—	—	—	—	—
Stevens Institute of Technology	4	12	15	1	—	—	—
Suffolk U	3	6	—	—	—	—	—
Susquehanna U	3	1	—	—	—	—	—
Swarthmore C	4	6	—	—	—	—	—
Syracuse U	7	7	2	4	21	2	1
Temple U	9	12	2	2	—	—	—
Tennessee Tech U	4	17	1	—	14	11	—
Tennessee, U of							
Knoxville	2	20	6	13	35	6	1
Chattanooga	13	19	—	—	—	—	—
Martin	3	14	—	—	—	—	—
Texas A&I U	2	0	1	—	(e)	—	—
Texas A&M U	12	9	6	21	110	5	2
Texas Christian U	6	4	3	2	—	—	—
Texas Southern U	20	0	10	—	—	—	—
Texas Tech U	7	10	7	5	(e)	—	—
Texas, U of							
Arlington	15	16	6	—	—	—	—
Austin	56	0	6	16	82	15	5
Dallas	2	2	1	—	—	—	—
El Paso	11	1	10	—	—	—	—
Texas Woman's U	1	4	1	3	—	—	—
Thiel C	4	12	—	—	—	—	—
Thomas More C	3	5	—	—	—	—	—
Toledo, U of	1	14	1	1	23	3	1
Towson State U	9	8	—	—	—	—	—
Trenton State C[a]	9	3	—	—	—	—	—
Trinity C	9	5	0	—	—	—	—
Trinity U	1	2	0	—	—	—	—
Tri-State U[b]	(a)	—	—	—	—	—	—
Tufts U	0	48	1	1	33	2	0
Tulane U of Louisiana	0	28	3	2	(e)	—	—
Tulsa, U of	4	0	—	—	32	12	0
Tuskegee Institute	1	1	2	—	—	—	—
Union C	3	18	1	—	—	—	—
U.S. Air Force Academy	12	0	—	—	—	—	—
U.S. Naval Academy	20	0	—	—	—	—	—
Ursinus C	10	12	—	—	—	—	—
Utah State U	8	0	2	3	—	—	—
Utah, U of	4	38	8	10	29	13	1
Valparaiso U	4	25	—	—	—	—	—
Vanderbilt U	3	41	4	5	22	2	1
Vassar C	1	2	1	—	—	—	—
Vermont, U of	13	0	0	5	—	—	—
Villanova U	8	0	3	1	25	8	—
Virginia Commonwealth U	3	20	5	1	—	—	—
Virginia Military Institute	15	0	—	—	—	—	—
Virginia Polytechnic Institute & State U	18	12	7	9	58	8	1
Virginia, U of	10	52	1	4	39	27	1
Wabash C	9	11	—	—	—	—	—
Wagner C	9	11	—	—	—	—	—
Wake Forest U	0	38	3	0	—	—	—
Washburn U of Topeka	1	5	—	—	—	—	—
Washington C	6	0	—	—	—	—	—
Washington and Jefferson C	4	26	—	—	—	—	—
Washington and Lee U	0	5	—	—	—	—	—
Washington State U	13	9	2	8	32	6	3
Washington U	15	1	15	2	63	7	4
Washington, U of	39	20	15	9	86	17	3
Wayne State U	15	38	11	13	(e)	—	—
Waynesburg C	4	1	—	—	—	—	—
Weber State C	4	3	—	—	—	—	—
Wellesley C	1	26	—	—	—	—	—
Wells C	1	0	—	—	—	—	—
Wesleyan U	5	9	0	4	—	—	—
West Chester State C	6	13	1	—	—	—	—
West Florida, U of	9	1	—	—	—	—	—
West Texas State U	1	8	6	—	—	—	—
West Virginia Institute of Technology	1	0	—	—	(e)	—	—
West Virginia State C	3	4	—	—	—	—	—
West Virginia U	9	36	5	3	37	11	5
Western Illinois U	3	0	1	—	—	—	—
Western Kentucky U	6	10	6	—	—	—	—
Western Maryland C	2	4	—	—	—	—	—
Western Michigan U	6	24	7	1	—	—	—
Western New England C	0	1	—	—	—	—	—
Western Washington U	6	11	4	—	—	—	—
Westminster C	0	6	—	—	—	—	—
Wheaton C (Illinois)	1	12	—	—	—	—	—
Wheaton C (Massachusetts)	1	11	—	—	—	—	—
Wheeling C	1	3	—	—	—	—	—
Whitman C	4	10	—	—	—	—	—
Whittier C	0	6	—	—	—	—	—
Wichita State U	5	3	4	0	—	—	—
Widener C	6	4	—	—	—	—	—
Wilkes C	6	3	0	—	—	—	—
Willamette U	1	8	—	—	—	—	—
William and Mary, C of	6	24	0	—	—	—	—
Williams C	6	26	—	—	—	—	—
Wisconsin, U of							
Eau Claire	4	21	—	—	—	—	—
Green Bay	0	6	—	—	—	—	—
La Crosse	2	22	—	—	—	—	—
Madison	14	9	12	49	88	8	11
Milwaukee	3	24	8	9	—	—	—
Oshkosh	6	3	—	—	—	—	—
Parkside	16	6	—	—	—	—	—
Platteville	1	3	—	—	—	—	—
River Falls	3	8	—	—	—	—	—
Stevens Point	1	6	—	0	—	—	—
Superior	1	3	—	—	—	—	—
Wittenberg U	9	11	—	—	—	—	—
Wooster, C of	4	29	—	—	—	—	—
Worcester Polytechnic Institute	0	13	1	0	41	5	2
Wright State U	22	19	16	—	—	—	—
Xavier U (Ohio)	7	9	2	—	—	—	—
Xavier U of Louisiana	1	8	—	—	—	—	—
Yale U	23	6	36	11	—	—	—
Youngstown State U	6	8	4	—	15	—	—
TOTALS	**4424**	**6027**	**1716**	**1532**	**4977**	**951**	**237**

a Added in 1979. **b** Listed on basis of accreditation by AIChE-ECPD. **c** The chemistry programs at Mount Saint Vincent College and Manhattan College are integrated into a combined department with all instruction in chemistry located at Manhattan College. **d** Master's degrees given by Atlanta University. **e** Data not submitted. **Note:** For brevity, "B.S." and "M.S." are used to denote all bachelor's and master's degrees, respectively, in each column.

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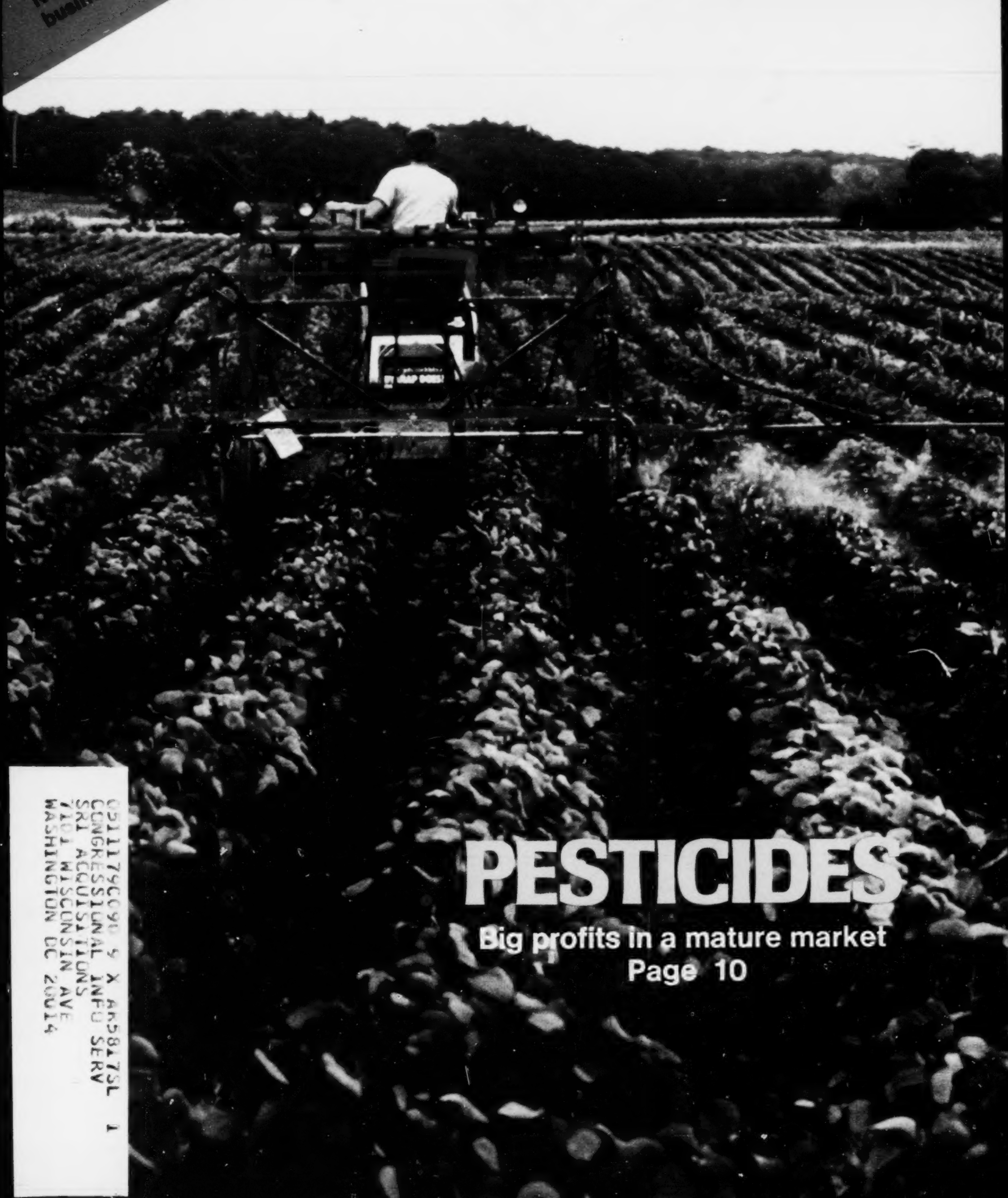
Chemical & Engineering NEWS

April 28, 1980

New policies emerge for small business innovation Page 14



PESTICIDES

Big profits in a mature market
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- ***Use of miniature labeling devices*** *in commercial explosives could deter terrorists, says OTA report.* ***Page 7***
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CHEMICAL EARNINGS SOAR IN FIRST QUARTER

To get a rough estimate of how a U.S. chemical company did in the first quarter of 1980, an outsider need ask only a few questions. How much of its business was in chemicals and plastics close to oil and natural gas? That is very good. How much in agricultural chemicals? Also good. How much in downstream specialties? Not so good. How much in synthetic fibers? Bad. And how much in products going into autos and housing? Very bad.

For the industry as a whole, big profits gains in basic chemicals, plastics, and agricultural chemicals more than outweighed earnings drops in some specialties, fibers, and auto and housing products. As a result, for 20 of the largest U.S. basic chemical companies surveyed by C&EN earnings increased 49% in first-quarter 1980 over first-quarter 1979. Sales advanced 21%. Profit margins on sales rose to 8.5% from 6.9% a year ago.

These gains are somewhat overstated, not just because of standard inflation factors, but because of some unusually large nonoperational gains at some companies. The most important of these by far was a nonrecurring $217.3 million gain at Union Carbide due to major accounting changes (C&EN, Jan. 28, page 6). Without these nonrecurring gains, the industry's earnings rose 30% year-to-year in the first quarter, and the profit margin increased to 7.3%.

At Carbide itself, the more realistic earnings gain, without the accounting changes and with all 1979 figures estimated on a comparable basis, was about 44% in the first quarter of 1980 (41% on an earnings-per-share basis). Carbide's formal earnings figures for the new quarter, including the accounting changes, show an earnings increase of 251%. Carbide's sales increased 19%.

But with or without the nonrecurring earnings figures, the industry's earnings performance in the first quarter was a new peak in both a long business expansion since 1975 and in its all-time record. The 30% earnings gain in the quarter without nonrecurring items was on a par with gains in the previous five quarters since fourth-quarter 1978. The 21% sales gain also was in line with increases since the final quarter of 1978. In other words, the industry's favorable part of the current business cycle has stretched to a year and a half, far longer than many industry economists expected.

However, the celebrating in company reports for the first quarter is notably restrained. Company chiefs see major parts of their business now in the grip of a downturn (probably the first warnings of a spread to other product lines) and feel the bite of big increases in production costs, some of which can no longer be passed along to customers.

The result is some pretty toned-down forecasts for the rest of 1980. For example, Rohm & Haas chairman Vincent L. Gregory Jr. observes that there is little doubt that the U.S. economy is moving into a recession. He notes, as do other industry executives, that the company has kept tight control on inventories, capital spending, and employment, and so should be able to weather the expected contraction.

However, Gregory admits that the company's selling price increases have not quite kept pace with cost increases, causing a drop in profit margins. A weakening economy and continued upward cost pressures make him anticipate continued pressure on profit margins.

A company further along in this cost-price squeeze is Du Pont, whose president, Edward G. Jefferson, told stockholders last week at the company's annual meeting that in the first quarter Du Pont's profit margin on sales sank to 6.9% from 8.4% a year earlier, with particular damage to synthetic fibers.

Perhaps the brightest side of the chemical industry at the moment is fertilizer and pesticides, which greatly aided profits at companies such as Freeport Minerals and Texasgulf. ☐

First quarter brought a sizable overall profit margin increase

	FIRST QUARTER							
	Sales			Earnings			Profit margin[a]	
$ Millions	1980	1979	% change	1980	1979	% change	1980	1979
Air Products	$378.0	$299.3	26%	$34.2	$24.5	40%	9.1%	8.2%
Akzona	293.2	260.1	13	5.3	9.3	−43	1.8	3.6
American Cyanamid	830.0	753.3	10	38.0	40.7	−7	4.6	5.4
Celanese	847.0	745.0	14	36.0	32.0	13	4.3	4.3
Diamond Shamrock	755.3	505.0	50	56.3	29.5	91	7.5	5.8
Dow Chemical	2,809.5	2,075.4	35	230.5	176.5	31	8.2	8.5
Du Pont	3,567.9	3,020.9	18	244.4	248.4	−2	6.9	8.2
Ethyl[b]	438.6	370.6	18	28.5	21.1	35	6.5	5.7
Freeport Minerals	196.4	105.4	48	35.3	20.2	75	22.6	19.2
W. R. Grace[b]	1,362.0	1,165.9	17	65.1	57.1	14	4.8	4.9
Hercules	646.0	555.0	16	33.7	36.1	−7	5.2	6.5
International Minerals[b]	459.5	374.5	23	39.1	32.7	20	8.5	8.7
Olin	475.2	437.2	9	22.1	17.5	26	4.7	4.0
Pennwalt	302.8	259.3	17	12.3	10.0	23	4.1	3.9
Reichhold Chemicals[b]	236.3	203.4	16	4.2	2.6	62	1.8	1.3
Rohm & Haas[b]	435.7	384.4	13	27.1	28.2	−4	6.2	7.3
Stauffer Chemical	582.9	498.7	17	69.6	62.2	12	11.9	12.5
Texasgulf	280.0	174.3	61	73.6	25.3	191	26.3	14.5
Union Carbide[b]	2,565.6	2,164.8	19	437.2	124.6	251	17.0	5.8
Wilco Chemical	285.6	221.6	29	10.5	9.3	12	3.7	4.2
TOTAL[b]	**$17,707.5**	**$14,574.1**	**21%**	**$1503.0**	**$1007.8**	**49%**	**8.5%**	**6.9%**

[a] After-tax earnings as per cent of sales. [b] Major nonoperational influences on earnings include a $7.3 million gain at Ethyl in first-quarter 1980, a $17.1 million gain at W. R. Grace in first-quarter 1979, a $7.9 million loss at International Minerals in first-quarter 1980 (third fiscal quarter), a $1.9 million foreign exchange gain at Reichhold Chemicals in first-quarter 1980 compared to a gain of $0.4 million in first-quarter 1979, a $3.7 million gain at Rohm & Haas in first-quarter 1979, and a $217.3 million gain for accounting changes at Union Carbide in first-quarter 1980. Without these factors, total earnings in first-quarter 1980 would have been $1284.4 million, an increase of 30% from $986.6 million in first-quarter 1979. Profit margins would have been 7.3% in first-quarter 1980 and 6.8% in first-quarter 1979.

Pesticide profits belie mature market status

Price increases and exports are likely to keep profits strong despite little growth in U.S. market and sharply rising raw materials costs

William J. Storck
C&EN, New York

Pesticide producers in the U.S. are expecting another good year in 1980. Production will be up a modest 3 to 5%, but prices are likely to climb at least 10%. Pesticides' important export poundage once again probably will increase. Thus dollar sales of pesticides produced in the U.S. will continue their steady, highly profitable gains. At no time in the past decade have dollar sales of pesticides fallen.

Oddly, the pesticide market is often described as mature. However, this market defies the usual definition of mature, which implies modest profitability as well as low growth.

In terms of production and sales volume of pesticides in the U.S., the market does indeed appear to be mature. During the past decade, production has increased only about 44% (4% per year), and shipments have climbed only about 47%. Consumption within the U.S. has not regained the peak it reached in the mid-1970's.

However, in terms of sales dollars, the market appears to be anything but mature. During the 1970's prices about tripled, and the value of U.S. production increased about 350% to about $4.2 billion.

In terms of profitability to pesticide producers the market does not look very mature either. Operating (pretax) profit as a percentage of sales ranges from about 20% to more than 40% among U.S. producers. This is a far cry from a mature, low rate of profitability.

Another term that doesn't apply well to pesticides is industry concentration. Some have described the pesticide industry as highly concentrated, that is, limited to a small number of producers. In one sense it is, but by strict definition, it is not.

The discrepancy lies in the nature of the industry. On the one hand, the pesticide industry taken as a whole does not seem to be very concentrat-

Herbicides consumption to grow 5% in 1980

U.S. producers of herbicides expect volume to grow about 4 to 5% this year over 1979. Prices may increase 8 to 12%. Thus, revenues to herbicides producers in 1980 may be up 12 to 15% over 1979.

Growth in herbicides is tied closely to specific markets. For example, producers say that the market for herbicides for soybeans is growing tremendously, to the point that it will soon rival corn as the largest herbicide market in the U.S.

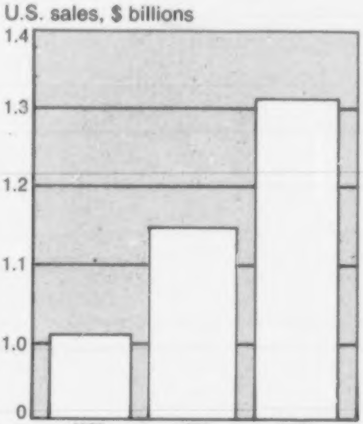
The Department of Agriculture estimates that capacity utilization for herbicide plants in 1980 will be about 77%, up from 74% in 1979. At the same time, production capacity will be expanded about 2%. Capacity utilization and capacity in general are tricky measures of herbicide performance, however, since capacity use for one herbicide can be high while for another it is low.

Like almost every other type of chemical producer, herbicide producers are finding themselves in a cost-price squeeze as the cost of raw materials increases. This is causing producers to consider a change in their pricing methods. According to one company, prices traditionally have been set at the beginning of the planting season, to remain in effect until the next year. That producer is now reviewing prices on a monthly basis so that increases in raw material costs can be passed along.

Herbicide exports are expected to remain strong, amounting to about one sixth of production and 25% of U.S. dollar volume.

The big news in herbicides is postemergent sprays. For the past decade or more, most herbicides have been applied to fields before crop planting. Companies are now working on herbicides that are sprayed on the crops after they have started to grow.

Postemergent herbicides are more expensive than pre-emergents on a cost-per-pound basis, perhaps 50% more. However, on an operational cost-per-acre basis, the difference is smaller, because the grower makes fewer total trips through the field.



One other advantage of postemergents, producers add, is that the growers can identify the weeds they have to kill before spraying. Since herbicides, and indeed all pesticides, are becoming increasingly specific in their actions, postemergent application allows the farmer to determine exactly what he or she must kill before spraying.

The postemergents also are sprayed, in some cases, after the crop is high enough to establish a "canopy," which shades the soil from the sun. This deprives newly sprouting weeds of essential sunlight and prevents them from surviving.

Producers admit that the market for postemergent herbicides is presently small—about $20 million in 1980. However, they predict this market will grow to about $100 million by 1985.

Overall, producers believe that 1980 will be a good year for herbicides. However, they won't be sure until the last dollar is counted, since there are so many variables—how much acreage the farmers plant, how much herbicide farmers decide to spray, and how much raw material costs increase.

ed. There are more than 50 firms in the U.S. making pesticides of one kind or another, and of these, 14 firms account for about 85% of sales. Although this is moderately concentrated, it is nothing like concentration in many chemical commodities and, indeed, in some other specialties, where two or three firms dominate the market.

On the other hand, if one breaks down the industry into specific pesticide products, it is concentrated. A few firms may dominate the market for, say, corn herbicides or tobacco plant growth regulators. Further entry into these markets may be barred effectively by the grower's buying habits and by the high cost of developing new, safe pesticides.

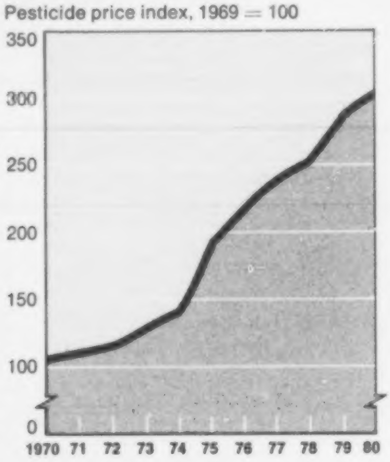
A timely example of this is the relatively new market for synthetic pyrethroid insecticides. Three firms in the U.S.—Shell, ICI Americas, and FMC—are heavily involved in research, development, and marketing of these compounds. The potential for pyrethroids seems to be very great, according to pyrethroid producers and producers of more traditional pesticides. But they all agree that if a company has not already made a substantial investment, it essentially will be shut out of the synthetic pyrethroid market, because of the market share that has been grabbed by the companies already involved.

The cost of entry to the pesticide market is indeed high. Besides the traditional costs of developing a compound and building the plant to produce it, there are costs of proving to the Environmental Protection Agency that the compound is safe. Proof to EPA costs time in addition to dollars. To hasten the process, most U.S. pesticide producers have established research facilities in warmer climates outside the U.S. to get at least two and perhaps three plantings per year for testing.

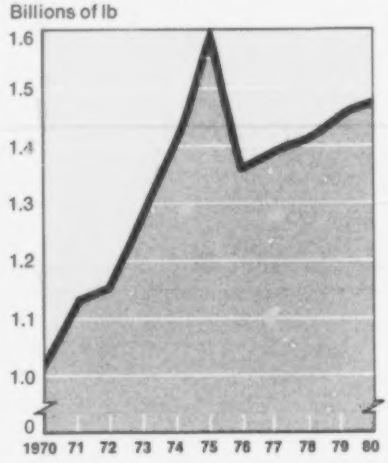
Testing outside the U.S. can provide another benefit. Producers often receive approval for pesticides from foreign countries before they do in the U.S. Thus, they can get some return on their investment by selling in the foreign markets while they are awaiting approval in the U.S.

An early start is very important to producers because of pesticides' limited patent life. In this respect, pesticides are like pharmaceuticals: By the time all the safety testing is completed, a significant portion of the patent life has elapsed. According to

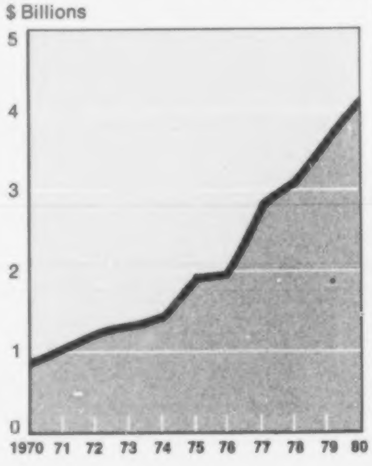
Pesticide prices have almost tripled in decade . . .



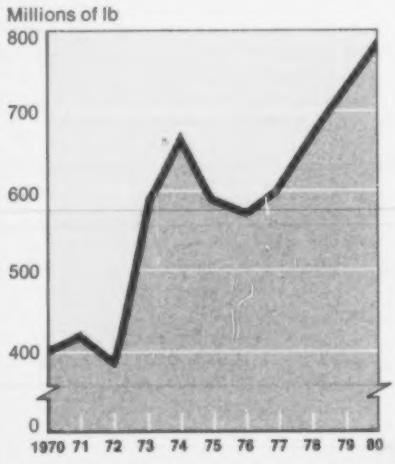
. . . while production has climbed 43% . . .



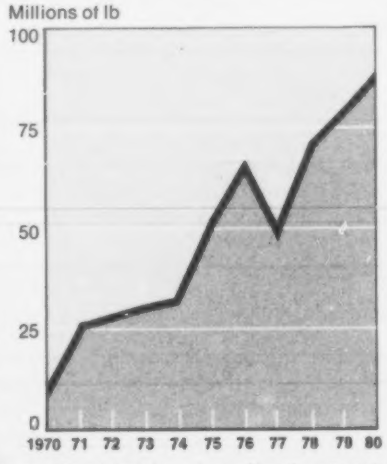
. . . causing value of U.S. production to surge 350%



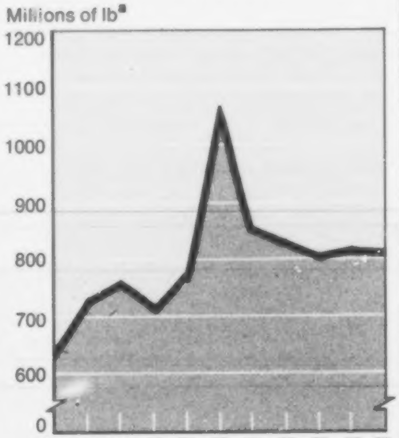
Pesticide exports nearly doubled in 1970's . . .



. . . and imports are up almost eightfold . . .



. . . but U.S. consumption peaked in mid-decade



[a] Apparent consumption is production minus exports plus imports. Exports include carriers and inert ingredients in volume. Other volumes are mostly on an active ingredient basis. **Sources:** Department of Agriculture, C&EN estimates

Insecticide fortunes to improve in 1980

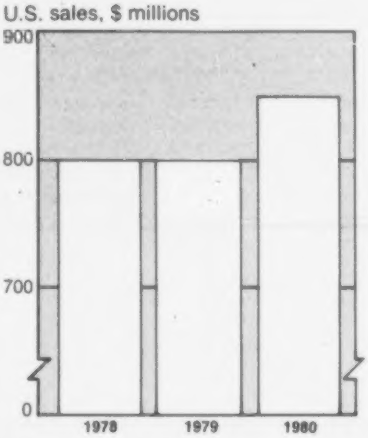
There is hardly any doubt that 1980 will be a better year for insecticide sales than last year. This is partly because 1979 was not a very good one for insecticide producers.

Use of insecticides is expected to increase 8 to 10% from 1979. However, production will not be up this much because of inventories carried over from last year. The U.S. government estimates that inventories are 38% greater than they were at the beginning of 1979.

A light infestation of insects in the cotton crop last year caused the increase in inventories. This left cotton growers with some carry-over at the end of the season. However, producers say that such a light infestation is unusual two years in a row. Therefore, although the inventories likely will be used by cotton growers in 1980, insecticide production may be off somewhat because of them.

As with herbicides, insecticide prices are on the increase—up about 10% over last year. And they may go even higher if producers begin monthly price reviews.

However, insecticides are not a fast-moving market. One consultant tells C&EN that the dynamics of the insecticide industry are dictated by insects' slow rate of developing resistance to existing insecticides. Although this may be an oversimplification, it is true that the insecticide market in the U.S. remained at a static $800 million in 1979. In 1980, it is expected to increase to about $850 million, mainly because of price increases.



As is the case with herbicides, a large proportion of U.S. production of insecticides (about one third) is shipped overseas. Imports make up less than 1% of U.S. supply.

Also like herbicides, there is a relatively new development in insecticides. This is the synthetic pyrethroids. These insecticides, which are a synthesized version of the extract of the pyrethrum flower, are much more biologically active than are traditional insecticides. Thus, application rates are much lower—in some cases one 10th the rates of more traditional insecticides such as organophosphates.

However, pyrethroids cost more. It costs about $3.85 per acre for a mixture of organophosphates compared to about $6.00 per acre for synthetic pyrethroids. The question then becomes: Are the benefits worth the additional cost?

Some producers are betting that they are. Producers of synthetic pyrethroids say that the product is "supereffective." They claim that besides killing insects it has no negative effect on plant growth. Indeed, plants seem to mature earlier when treated with the pyrethroids. Producers also say that pyrethroids are very specific for insects and have absolutely no effect on livestock or humans. One other apparent benefit is that, thus far, producers have seen no resistance to these compounds built up in insects.

Producers also claim that although the cost per acre for pyrethroids is high, the cost per crop may not be. They say that fewer applications may be needed because of the greater effectiveness of pyrethroids and because of a shorter growing season due to the earlier maturity pyrethroids afford crops.

Evidently cotton growers, who use most of the pyrethroids output, agree. Producers claim to have captured about 50% of the market for control of worms in cotton after only two to three years. This amounts to explosive growth to about a $75 million market.

Pyrethroid producers also are seeing rapid growth in use of their product for vegetables, and field corn and soybeans offer good potential. In fact, growth is so fast that producers can cite no accurate estimate of eventual size other than "very big."

some estimates, the time during which developers can recoup their investment on a pesticide is eight to 10 years of the 17-year U.S. patent life.

After a patent expires, generic producers can enter the marketplace, increase competition, and drive down prices and profits.

Producers point to atrazine, one of the leading herbicides for corn, as an example. The patent held by Ciba-Geigy expired, and at least two other companies entered the market. The result was that the price of atrazine to corn growers fell considerably. Producers try to get around this somewhat by trying to delay patent issuance as long as possible after the initial filing.

For the long term, there is one practice evolving that will have tremendous impact on pesticide producers—integrated pest management. Under this concept, all types of pest control—cultural, chemical, inbred, and biological—are integrated to control all types of pests.

The chemical controls include all of the traditional pesticides. Cultural controls consist of cultivation, crop rotation, optimum planting dates, and sanitation. Inbred plant resistance involves the use of varieties and hybrids that are resistant to certain pests. And biological control involves encouraging natural predators, parasites, and microbials.

Under this system, pest detection scouts measure pest populations and determine the best time for applying pesticides. According to a study by the Office of Technology Assessment, integrated pest management could reduce pesticide use up to 75% on some crops.

There are two big problems with integrated pest management, however. The first is getting farmers to accept the concept. In many cases, they prefer to spray one chemical to control everything rather than spray for specific pests. As evidence of this, the biggest insecticides in terms of sales are still nonspecific, broad-band chemicals. A second and related problem is expanding the program from its relatively small base to one that is nationwide. This will not happen until a way is found to get full acceptance from farmers and to train enough scouts to carry out the program.

So for the time being, pest control probably will remain as it has been. Producers are going to sell increasing amounts of pesticides at higher prices. Over the next five years, volumes are slated to increase from 2 to 7% annually. And price increases probably will average at least 10% per year.

For 1980, farmers are expecting a good planting season. And if all conditions were normal, U.S. pesticide producers would be looking forward to the coming year. However, there are some big uncertainties. One is how much pesticide farmers will use this year. Producers say that farmers' financial liquidity is very low. This, combined with high interest rates, may cause them to think twice (or even more) about high application rates of pesticides. Growers may decide that they can cut their pesticide applications without cutting their financial return too much.

However, producers still figure that pesticide use will increase at least 3% over last year. Thus sales would be up 12 to 15%.

Capacity use at pesticides plants is due to decline somewhat to about 78% this year from 80% in 1979, according to a survey by the Department of Agriculture. Most of this decline will be in insecticides.

Exports of pesticides likely will continue to grow but at a slower rate than in the 1970's. This is largely due to increased production capacity in foreign countries.

At the same time, raw materials and energy costs for making pesticides are expected to continue rising. Pesticides, which are in many cases petroleum-based, are not increasing in price fast enough to make up for the increases in raw material cost. For example, according to one estimate, the cost of solvent to producers will increase at least 25% in 1980. However, raw material availability seems to be no problem at these higher prices.

Thus, a few uncertainties notwithstanding, it's likely that 1980 will be another fairly good year for pesticide producers with prices up, use up, and profit margins under pressure but still high. ☐

Plant growth regulators: good growth, small market

Plant growth regulators have the smallest market among all the major pesticide categories—about $129 million in the U.S.—but they also show the fastest growth.

Producers project that plant growth regulators will continue their historic, 11% growth in volume through the next two years. After that they expect growth to slow somewhat.

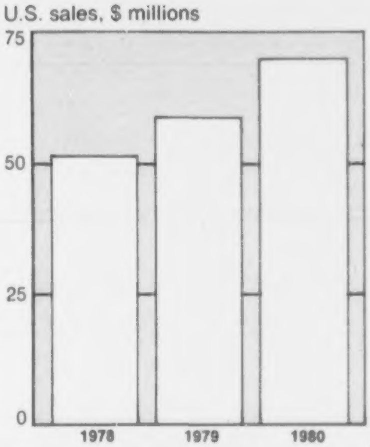
The plant growth regulator market is made up of two distinct entities—growth regulators and harvest aids. Growth regulators are used to increase crop yield or quality. Harvest aids, as the name implies, are used at the end of the crop cycle. For instance, harvest aids defoliate cotton before picking or desiccate potatoes before digging.

The largest U.S. market for plant growth regulators is indeed in harvest aids for defoliating cotton. The market value for this is about $23 million. This is followed by the tobacco market, where growth regulators control "suckers," thus increasing yield. Value of this market is about $12 million in the U.S. PGR exports are very small compared to other pesticides.

Producers say that plant growth regulators are priced on a very high value-added basis, since they are used to decrease labor or to enhance crop yield. Price increases for 1980 generally fall in line with the rest of the pesticide industry at about 8 to 12%.

Unlike herbicides or insecticides, however, there are no big new developments in plant growth regulators, and this worries producers.

In fact, for most of the big use regulators, patents either have expired or will expire in the near future. Thus, generic producers of regulators are making inroads on the market. For example, Uniroyal's maleic hydrazide, used on tobacco and potatoes, has been off patent for some time, and other producers have entered the market. In another case, GAF has broken Union Carbide's Amchem division's patent for Ethrel, a ripening aid, and the two companies are in court over it.



The big problem is that there has been a tremendous gap in development of new plant growth regulators. There has been no development of a potentially large-volume plant growth regulator in years. Thus, generic producers are able to take away market share in the older, larger markets.

The big work now is to find products for use on high-volume crops such as corn. Producers say that they are now looking at pioneering biochemical developments. In these, the biochemical process of the plant would be interrupted to produce beneficial results.

In a crop such as corn, for instance, producers are trying to develop a substance to enhance the starch-making process. Some of the starch that is produced by the plant is consumed as energy. If producers can develop a substance that will produce more starch, it will lead to healthier plants and bigger yields than farmers are now getting.

CHECKOFF

NEW PLANTS

■ **Aluminum.** Martin Marietta Aluminum plans to expand capacity of its reduction plant at Goldendale, Wash., from 120,000 tons to 185,000 tons of aluminum per year at a cost of $125 million. Kaiser Engineers Inc., subsidiary of Raymond International, will handle engineering and other work on the project, which is scheduled to be completed by late 1981.

■ **Fertilizer.** Union Oil plans to build 200,000 ton-per-year liquid urea-ammonium nitrate (UAN solution) plant west of Sacramento, Calif. Plant will cost $10 million and be completed by spring 1981.

■ **Oxygenated organics.** Oxirane Chemical will debottleneck units at Bayport, Tex., plant to increase output of propylene oxide about 100 million lb annually and of *tert*-butyl alcohol about 440 million lb annually. When work is completed at end of 1980, capacities will be 1 billion lb propylene oxide and 2.0 to 2.5 billion lb *tert*-butyl alcohol.

■ **Polyethylene.** Exxon Chemical plans to build 200,000 ton-per-year, high-density polyethylene plant at Mont Belvieu, Tex. Exxon will use technology licensed from Asahi Chemical Industry Co. of Japan involving modified Ziegler-type catalyst; plant scheduled for completion in 1983.

■ **Polyethylene.** Allied Chemical will expand capacity for its line of low-molecular-weight polyethylenes at Orange, Tex., 25% to unspecified level; plant scheduled for completion in late 1981.

PLANTS COMPLETED

■ **Alkylphenols.** GAF Corp. has expanded capacity of its Linden, N.J., plant for these intermediates used in surfactants at a cost of $1 million; size of expansion not disclosed.

■ **Ethanolamines.** Texaco has reached planned operating levels at new plant at Port Neches, Tex. Plant doubles company's capacity to 150 million lb a year.

Chemical & Engineering **NEWS**

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News of the Week

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- ***Allied Chemical chairman Edward Hennessy*** *plans acquisitions, higher research spending, change in company name.* ***Page 4***
- ***Manufacture of six new chemicals*** *has been banned by EPA until company provides data that they are not hazardous.* ***Page 5***
- ***New York state sues Hooker Chemical*** *over chemical waste dumped at Love Canal near Niagara Falls.* ***Page 5***
- ***Marketing process that recovers coal fines*** *by removing sulfur and ash and pelletizing is aim of newly formed company.* ***Page 6***
- ***Inventory of federal regulatory reforms*** *undertaken by 36 agencies between 1978 and 1980 has been issued.* ***Page 6***

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International

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C&EN's Top Fifty

Production of top 50 industrial chemicals *in the U.S. increased 8% in 1979 to 565 billion lb; 50 largest companies boosted sales 25% to $90 billion.* ***Page 33***

ACS News

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Chemical firms feel cash pinch

Though profits are way up and new investment projects moderate, day-to-day needs for financing prevent cash increase at chemical firms

William F. Fallwell
C&EN, New York

Late in a business expansion when things get a bit overheated, companies typically make more money but see it immediately sopped up by ambitious investment projects and increased day-to-day financing needs. The financing drain results from a big increase in tideover money needed as inventories build up and customers delay payments. As a result, "liquidity" (cash and relative cash coverage of liabilities) declines.

This time around in the U.S. basic chemical industry, the business peak in the past year brought a peculiar version of this general case. Chemical companies have kept their investment goals moderate, increasing them relatively less than either profits or cash flow (profits plus depreciation). However, despite companies' best efforts at control, financing needs have swollen.

The result is much the same as in past expansions. Companies' cash is being hit and key financial ratios knocked down. A few companies have bucked the tide, but the industry as a whole has found the financing surge a strenuous challenge.

A C&EN survey of 20 leading basic chemical companies finds no net gain in cash, including short-term investments convertible into cash, from the end of 1978 to the end of 1979. By contrast, in 1978, cash and marketables jumped 30% at these companies from a year earlier.

At the same time, the average unweighted "current ratio" at these companies dropped a notch to 2.0 at the end of 1979 from 2.1 at the end of 1978. The current ratio is current assets divided by current liabilities.

More serious, companies' coverage of current liabilities with cash and marketables sank to 19% at the end of 1979 from 23% a year earlier. At the end of 1977, this figure had been 28%.

For comparison, the same 20 companies stood more conservative on these ratios at the top of the previous expansion in the heady days of 1974. That year, the current ratio wound up at 2.2, and cash coverage of current liabilities ended at 28%. Still, these companies' cash was depleted 17% in 1974 from 1973—a worse showing than in 1979.

Since 1974, these companies' total of cash and marketables has grown only 13%, although profits have increased more than 40%. This despite

Companies had no cash gain in 1979 as financial ratios declined

	1979			1978			1977			1974		
	Cash and marketables ($ millions)	Current ratio	Cash ratio	Cash and marketables ($ millions)	Current ratio	Cash ratio	Cash and marketables ($ millions)	Current ratio	Cash ratio	Cash and marketables ($ millions)	Current ratio	Cash ratio
Air Products	$ 47.0	1.4	0.15	$ 38.7	1.2	0.14	$ 55.9	1.5	0.27	$ 45.8	1.4	0.28
Akzona	18.5	2.2	0.10	11.4	2.5	0.09	9.4	2.7	0.09	9.0	3.2	0.11
Allied Chemical	125.8	1.2	0.09	90.3	1.4	0.14	42.7	1.7	0.09	72.8	2.0	0.22
American Cyanamid	146.2	1.6	0.18	97.7	1.8	0.15	110.7	2.0	0.22	179.4	2.4	0.54
Cabot	19.3	2.0	0.08	26.9	2.5	0.18	67.1	2.6	0.61	25.2	2.4	0.28
Celanese	214.0	1.8	0.36	143.0	2.0	0.33	122.0	2.0	0.32	117.0	1.7	0.31
Diamond Shamrock	31.3	1.9	0.08	45.8	2.0	0.15	33.5	2.0	0.13	35.5	1.4	0.16
Dow Chemical	251.7	1.4	0.10	398.5	1.6	0.20	135.4	1.5	0.08	423.3	1.4	0.27
Du Pont	369.8	2.6	0.21	328.0	2.5	0.21	237.8	2.6	0.19	128.0	2.6	0.13
Ethyl Corp.	119.0	2.8	0.62	174.1	3.0	0.98	176.1	3.7	1.34	42.5	2.6	0.33
W. R. Grace	154.2	1.6	0.14	263.2	1.8	0.30	191.0	1.8	0.24	168.2	1.6	0.20
Hercules	56.3	1.9	0.14	57.9	1.9	0.15	29.1	2.2	0.11	22.2	2.0	0.08
Monsanto	271.3	2.2	0.24	347.6	2.5	0.39	198.3	2.6	0.30	324.1	2.9	0.63
Olin	25.6	1.8	0.08	31.0	1.7	0.09	32.1	2.0	0.12	98.2	2.3	0.46
Pennwalt	17.9	2.2	0.09	6.5	2.2	0.04	20.5	2.7	0.16	2.2	2.0	0.01
Reichhold Chemicals	10.2	2.1	0.09	6.8	2.1	0.07	9.2	2.1	0.10	22.8	2.3	0.45
Rohm & Haas	69.6	2.3	0.25	64.0	2.4	0.27	14.6	2.6	0.08	19.7	2.3	0.10
Stauffer Chemical	55.9	1.7	0.14	89.0	2.0	0.28	96.8	2.7	0.48	53.6	2.5	0.39
Union Carbide	449.0	2.2	0.26	283.7	2.0	0.18	323.1	2.2	0.23	426.1	2.2	0.38
Witco Chemical	72.6	2.0	0.41	25.4	2.0	0.22	33.9	2.5	0.44	14.6	1.9	0.18
TOTAL (average for ratios)	**$2525.2**	**2.0**	**0.19**	**$2529.5**	**2.1**	**0.23**	**$1939.2**	**2.3**	**0.28**	**$2230.2**	**2.2**	**0.28**
ANNUAL CHANGE	**0%**			**30%**								

Note: Current ratio is current assets divided by current liabilities. Cash ratio is cash and marketables divided by current liabilities.

the tempting opportunities to use free money to take advantage of mushrooming interest rates on short-term investments. Some of the largest chemical companies built up large cash hoards in 1978 (C&EN, May 7, 1979, page 10), but the going got much rougher in 1979.

A C&EN survey on some of the current main financing needs at chemical companies shows the pressure on funds during 1979. At the 20 leading chemical companies, inventories (in dollars) rose 19% during the year, even though companies made vigorous efforts to hold the line.

Receivables (uncollected bills to customers) rose 22% at these companies in 1979. Combined increases in receivables and inventories created a $4.1 billion financing drain for the year.

On the other side of the ledger, this group of chemical companies pushed up their own payables 34% in 1979. However, since payables are not nearly as large as receivables, this stretchout made up only $1.9 billion of the squeeze on funds from receivables and inventories.

Firms hiked debt and payables as inventories, receivables rose

	1979 FISCAL YEAR END							
$ Millions	Inventories	% change from 1978	Receivables	% change from 1978	Payables	% change from 1978	Short-term debt	% change from 1978
Air Products	$100.2	6%	$256.0	27%	$146.5	11%	$34.7	−13
Akzona	207.6	28	166.1	22	110.7	26	60.8	75
Allied Chemical	602.4	81	755.7	52	767.8	93	179.7	1942
American Cyanamid	515.4	3	689.9	21	569.7	24	200.7	43
Cabot	262.9	30	194.0	46	172.2	54	37.7	52
Celanese	352.0	11	463.0	21	349.0	33	65.0	51
Diamond Shamrock	316.2	32	443.1	39	232.2	46	35.7	−31
Dow Chemical	1,313.1	31	2,053.2	25	1,173.9	40	601.0	30
Du Pont	2,000.5	17	1,958.5	21	774.9	35	230.1	−11
Ethyl Corp.	162.7	20	250.8	22	135.4	9	21.3	2
W. R. Grace	767.4	8	729.4	16	446.9	23	264.6	12
Hercules	321.1	1	407.1	23	230.3	6	86.3	71
Monsanto	909.9	26	1,277.2	15	1,042.8	30	64.5	47
Olin	261.2	−1	290.3	13	134.5	−4	62.6	−19
Pennwalt	191.0	12	211.8	22	67.2	28	60.9	38
Reichhold Chemicals	81.5	0	129.2	19	76.5	19	14.6	−23
Rohm & Haas	282.1	20	277.8	15	206.4	33	38.8	−14
Stauffer Chemical	318.7	15	308.6	18	116.9	20	196.7	45
Union Carbide	1,773.6	15	1,433.3	14	528.0	22	207.5	−47
Witco Chemical	110.7	28	155.8	41	157.8	65	8.0	65
TOTAL	$10,850.2	19%	$12,470.8	22%	$7,439.6	34%	$2471.1	16

In addition, these companies' liabilities went up somewhat because of increased short-term debt, which rose a combined 16% or $300 million. However, 70% of this increase was accounted for by only two companies, Stauffer Chemical and acquisition-bent Allied Chemical. Seven companies actually drew down their short-term debt. Hence, chemical companies continued their reluctance in recent years to add much to borrowed funds—either short- or long-term.

Company-by-company through these surveys, the variations from the average were considerable in 1979. Unlike a year earlier, when any cash buildup was mainly by the largest companies, more of the medium-sized firms took part in 1979. All told, 11 of the 20 companies increased cash and marketables in 1979 over 1978. Of the top nine companies with more than $100 million in this category, five increased their holdings.

The top cash-laden chemical company in 1979 was Union Carbide, with $449 million, 58% more than in 1978. At others in the large-company group, cash increased 13% at Du Pont to $370 million, 50% at Celanese to $214 million, 50% at American Cyanamid to $146 million, and 39% at Allied Chemical to $126 million.

Some medium-sized companies had large percentage cash gains in 1979—21% at Air Products, 50% at Reichhold Chemicals, 62% at Akzona, 175% at Pennwalt, and 186% at Witco Chemical.

However, there also were nine companies in the 20-company survey with cash declines in 1979. Some of the drops were steep—27% at Dow Chemical, 28% at Cabot, 32% at Diamond Shamrock and Ethyl Corp., 37% at Stauffer Chemical, and 41% at W. R. Grace & Co.

In the current ratio, performance in 1979 was not nearly as evenly split as in cash and marketables. Only four companies managed a gain—Air Products, Du Pont, Olin, and Union Carbide. At 12 other companies, the ratio went down, and at four companies, the ratio stayed the same.

The cash ratio (cash divided by current liabilities) increased for eight companies in 1979, declined for 11, and stayed even for one.

Compared to performance in 1978, the company breakdown looks much the same in 1979 on liquidity measures. In both years, cash increased at about as many companies as declined, and the cash ratio fell at a few more companies than it went up. The higher total cash gain for the industry in 1978 was the result of some extraordinary increases at a few large firms.

In the current ratio, 1979 continued the dominance of declining numbers shown in 1978. However, a few more firms pulled this ratio up in 1979.

Among companies increasing their current ratio in 1979, there is considerable evidence of a campaign to tighten the balance sheet. Leaders in this area are Du Pont and Union Carbide. Nearly across the board, these two companies were more conservative or more controlled than the rest of the industry.

Union Carbide, besides gaining a large increase in cash to the industry's highest level, also came out higher than the industry average in both its current ratio and cash ratio in 1979. Both ratios for Carbide went up from 1978. Further, Carbide got through 1979 with below-average increases in inventories, receivables, and payables. Finally, the company cut its short-term debt 47% over the year.

Du Pont figures tell a similar story. While cash increased 13% in 1979, the current ratio stepped up to 2.6, the second highest among the 20 companies after Ethyl's 2.8. Du Pont's cash ratio stayed the same at 0.21. The company had below-average increases in inventories and receivables and a slightly higher than average increase in payables. Like Carbide, Du Pont lowered its short-term debt, by 11%.

With the U.S. economy likely entering a recession, chemical companies probably will head in the opposite financial direction. In a recession, typically, cash and the key financial ratios all increase, inventories decline, and gains in receivables and payables drop way down. That's what happened in 1975. Hence, by the end of 1980, many more companies may follow the more conservative trail blazed by a few in 1979. □

Special Report

50

C&EN's Top Fifty Chemical Products & Producers

Demand for chemicals in the U.S. held firm during 1979. Producers managed both to make effective use of expanded production capacity and to boost plant operating rates. And despite sharp increases in the cost of raw materials, the price of many U.S.-made chemicals gave them a distinct competitive advantage in several export markets. As a result, output of industrial chemicals remained on a high plateau throughout the year.

Output of the 50 industrial chemicals manufactured in greatest volume in the U.S. rose almost 8% in 1979 to a record 565 billion lb. The annual growth was nearly double the previous year's rate. All but eight of the products on C&EN's Top 50 compilation were produced in larger amounts in 1979 than in 1978, with output up more than 10% for 17 of them. And even for the handful for which output was lower, the decline was moderate at worst.

Organic chemicals had a particularly good year, reflecting in part a better-than-average growth for both plastics and synthetic fibers. Total production of the 29 organic chemicals included among the Top 50 jumped 15%, whereas the total output of inorganic chemicals on the list eked out an increase of only 4%.

Worldwide chemical sales of the Top 50 U.S. chemical producers, measured in dollars, scored a rousing 25% advance to a total of $90 billion in 1979—thanks, however, more to strongly rising prices than to higher output. The chemical operations of petroleum refiners, 14 of whom rank among the Top 50, made an especially strong showing because of heavy demand and higher selling prices for petrochemicals in both U.S. and foreign markets. All told, petroleum producers increased their chemical sales 40% during 1979 to more than $25 billion.

Last year, 32 of the 50 leading producers (including 12 petroleum companies) rang up chemical sales of more than $1 billion, eight more than had topped that figure the year before. And five of the 50 sold more than $5 billion worth of chemicals; in 1978 only Du Pont was above that lofty sales level.

50 C&EN's Top Fifty Chemical Products

Output rose last year for most big-volume chemicals

William J. Storck
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Last year, for the fourth straight year, total production of the 50 chemicals made in greatest quantity in the U.S. hit new highs.

Output of these chemicals was 565 billion lb. If production grows at the same rate in 1980 as it did in 1979, it will top 600 billion lb. However, production increases may, in fact, slow considerably this year.

The 565 billion lb chalked up last year represents an increase of 7.6% over the revised 525 billion lb of output of the Top 50 chemicals in 1978. The 1979 production figures are largely preliminary, however, so that growth rates may well change when final figures are available. When C&EN's Top 50 list was published last year, the preliminary figures showed a 5.3% increase in production over 1977. However, after the figures for 1978 were revised, the increase was only 4.2%.

Thus, growth for the Top 50 chemicals appears now to be greater than it was in 1978. This gain was led by the 29 organic chemicals on the list, whose output increased 14.8% to 190.2 billion lb from 166.1 billion lb in 1978. The inorganics increased just 4.3% to 374.4 billion lb from 359.1 billion lb in 1978.

It should come as little surprise that production was up strongly in 1979. The indications had been there all year. The Federal Reserve Board's production index for chemicals and allied products shows an increase of 6.6% over 1978. The increase in the index for basic chemicals was not quite so great as that for chemicals and allied products, but it was respectable, nevertheless. The index for basic chemicals averaged 190.9 for 1979, an increase of 4.9% above the 1978 average.

Both of these indexes showed much greater growth than did the much broader index for all nondurable

About the Top 50 list of chemical products

Government data, trade association figures, industry estimates. All of these go into preparing C&EN's annual list of the Top 50 chemical products, ranked by production volume. The federal government is relied upon most heavily, but when government figures are not available, other sources, primarily trade associations, are used. Industry sources and C&EN estimates are used only when other data are lacking or incomplete.

Government data are not always accurate—they are only as good as the information that individual companies report. But they are an objective measure of production extending back for many years. Therefore, relatively accurate indications of growth can be made on a consistent basis.

At this time of year, C&EN has access only to preliminary reports of production for 1979. When the government and trade associations issue their final reports, the outcome can be changed, sometimes dramatically. As a result, production figures for 1978 that appear in the table on page 35 may be different from those published at this time last year. The final reports also can affect the rankings of chemicals. The 1978 rankings of 31 of the chemicals listed in the table on page 35, for example, are different from those in the similar table published by C&EN a year ago.

The list itself covers production figures for the U.S., and includes chemicals produced for export. Candidates for the list include all basic, intermediate, and chemically homogeneous finished products. These range from chemical building blocks such as ethylene and propylene to finished products such as vinyl acetate and ethylene glycol.

The roster also includes basic inorganic chemicals, but does not include what C&EN considers to be minerals, such as salt, potash, gypsum, and sulfur. Lime is included because it is processed and has many chemical and industrial applications. Refractory (dead-burned) dolomite is excluded in the calculations of lime production.

In the organics, such petrochemical feedstocks as ethane, butane, and propane are excluded arbitrarily, because they are considered to be products of oil companies and because they have many nonchemical uses.

There are other gray areas besides lime and petrochemical feedstocks. For example, the basic aromatics—benzene, toluene, and xylene—are included. Admittedly, this makes the list less pure chemically. Mixed xylenes are on the list. So is the para isomer of xylene. If production volume had warranted, the ortho isomer also would be included.

Production figures are published by the government and trade associations in a variety of units—millions of pounds, thousands of tons, billions of cubic feet, millions of gallons, metric tons. To provide an accurate ranking and to make comparison of production volumes easier, C&EN not only gives production in common units but converts production to billions of pounds.

The Top 50 list, in addition to listing production figures for the past two years, indicates growth rates for the past year, the previous year, the past five years, and the past 10 years, giving the reader a historical perspective on growth for each chemical.

Organic chemicals provide most of Top 50 chemicals' growth in 1979

Rank			Production				Average annual change			
			Billions of lb		Common units[b]					
1979	1978[a]		1979	1978	1979	1978	1978–79	1977–78	1974–79	1969–79
1	1	**Sulfuric acid**	83.98	82.18	41,988 tt	41,088 tt	2.2%	7.1%	4.9%	3.5%
2	2	**Lime**[c]	38.78	38.78	19,392 tt	19,389 tt	0	2.4	−1.0	−0.1
3	4	**Ammonia**	36.24	33.89	18,121 tt	16,944 tt	6.9	−3.6	2.9	3.6
4	3	**Oxygen**	35.35	35.43	427 bcf	428 bcf	−0.2	8.9	1.8	4.5
5	5	**Nitrogen**	29.92	28.41	413 bcf	392 bcf	5.4	18.4	13.0	12.0
6	6	**Ethylene**	29.19	25.96	29,187 mp	25,955 mp	12.5	2.1	4.1	5.9
7	8	**Sodium hydroxide**	24.78	21.42	12,392 tt	10,710 tt	15.7	−2.0	2.1	2.3
8	7	**Chlorine**	24.22	21.92	12,108 tt	10,960 tt	10.5	3.7	2.4	2.6
9	9	**Phosphoric acid**	20.27	19.13	10,135 tt	9,563 tt	6.0	6.8	7.1	6.4
10	11	**Nitric acid**	17.13	16.10	8,564 tt	8,051 tt	6.4	1.3	1.1	1.7
11	10	**Sodium carbonate**[d]	16.51	16.58	8,253 tt	8,290 tt	−0.4	0	1.8	1.6
12	12	**Ammonium nitrate**[e]	15.60	14.41	7,800 tt	7,207 tt	8.2	0.4	0.7	2.9
13	13	**Propylene**	14.30	13.01	14,298 mp	13,013 mp	9.9	1.0	6.4	7.1
14	15	**Urea**[f]	13.53	10.89	13,534 mp	10,888 mp	24.2	22.5	12.3	8.6
15	16	**Benzene**	12.72	10.94	1,730 mg	1,488 mg	16.3	−3.1	3.0	3.9
16	18	**Toluene**[g]	11.86	7.64	1,636 mg	1,054 mg	55.2	−1.2	12.1	8.0
17	14	**Ethylene dichloride**	11.82	11.00	11,821 mp	11,001 mp	7.5	0	5.2	7.0
18	17	**Ethylbenzene**	8.53	8.39	8,530 mp	8,385 mp	1.7	0.9	7.1	5.7
19	20	**Vinyl chloride**	7.54	6.94	7,544 mp	6,941 mp	8.6	16.0	6.1	7.2
20	19	**Styrene**	7.48	7.19	7,484 mp	7,186 mp	4.0	4.6	4.7	4.9
21	22	**Methanol**	7.41	6.44	7,411 mp	6,443 mp	15.1	−0.2	1.5	5.8
22	25	**Terephthalic acid**[h]	7.26	5.95	7,263 mp	5,954 mp	22.0	10.1	11.3	13.9
23	21	**Carbon dioxide**[i]	7.07	6.69	3,533 tt	3,180 tt	5,7	12.9	13.0	11.7
24	24	**Xylene**[g]	6.89	6.13	950 mg	845 mg	12.4	0.7	3.4	9.5
25	23	**Formaldehyde**[j]	6.45	6.38	6,446 mp	6,380 mp	1.1	5.5	2.3	3.9
26	26	**Hydrochloric acid**	5.95	5.55	2,973 tt	2,773 tt	7.2	1.9	3.8	4.5
27	27	**Ethylene oxide**	5.28	5.01	5,277 mp	5,012 mp	5.4	14.8	4.7	4.5
28	28	**Ethylene glycol**	4.60	3.90	4,597 mp	3,903 mp	17.9	6.2	6.6	6.0
29	30	***p*-Xylene**	4.18	3.52	4,175 mp	3,516 mp	18.8	10.8	9.1	9.9
30	32	**Cumene**	4.00	3.38	3,995 mp	3,380 mp	18.3	27.8	6.6	9.0
31	29	**Ammonium sulfate**	3.94	3.87	1,971 tt	1,943 tt	1.8	−11.0	−1.4	0.3
32	31	**Butadiene (1,3-)**[k]	3.55	3.52	3,551 mp	3,515 mp	0.9	10.8	−0.7	1.3
33	34	**Acetic acid**	3.33	2.78	3,329 mp	2,775 mp	19.8	8.0	5.2	6.5
34	33	**Carbon black**	3.33	3.35	3,329 mp	3,346 mp	−0.6	−0.5	−0.1	2.3
35	35	**Phenol**[l]	2.95	2.68	2,945 mp	2,682 mp	10.1	14.7	5.1	6.1
36	36	**Acetone**	2.50	2.52	2,502 mp	2,519 mp	−0.8	13.5	4.8	5.1
37	38	**Aluminum sulfate**	2.46	2.37	1,232 tt	1,185 tt	3.8	−5.6	−0.3	−0.2
38	39	**Cyclohexane**	2.41	2.33	2,412 mp	2.331 mp	3.4	4.0	0.5	0.8
39	37	**Sodium sulfate**[m]	2.34	2.47	1,173 tt	1,239 tt	−5.3	3.4	−2.7	−2.3
40	41	**Propylene oxide**	2.25	2.05	2,249 mp	2,047 mp	9.8	9.7	5.1	6.7
41	40	**Calcium chloride**[n]	2.03	2.06	1,015 tt	1,031 tt	−1.5	6.6	−4.0	−1.4
42	42	**Acrylonitrile**	2.02	1.75	2,018 mp	1,752 mp	15.4	6.4	7.4	5.7
43	44	**Vinyl acetate**	1.98	1.69	1,983 mp	1,692 mp	18.6	6.7	7.2	10.5
44	43	**Isopropyl alcohol**	1.97	1.73	1,968 mp	1,730 mp	13.9	−8.4	0.3	−0.5
45	45	**Adipic acid**	1.80	1.62	1,800 mp	1,621 mp	11.1	5.6	4.0	4.0
46	46	**Sodium silicate**	1.55	1.60	777 tt	802 tt	−3.1	5.5	0.1	1.7
47	48	**Sodium tripolyphosphate**	1.51	1.47	756 tt	735 tt	2.7	2.5	−3.5	−4.6
48	47	**Acetic anhydride**	1.51	1.50	1,505 mp	1,500 mp	0.7	0	−1.6	−1.0
49	49	**Titanium dioxide**	1.48	1.43	741 tt	718 tt	3.5	4.5	−1.2	2.2
50	50	**Ethanol**[l]	1.31	1.27	1,308 mp	1,267 mp	3.1	−5.4	4.2	−5.7
		TOTAL INORGANICS IN TOP 50	**374.44**	**359.11**			**4.3%**	**4.5%**	**3.1%**	**3.2%**
		TOTAL ORGANICS IN TOP 50	**190.62**	**166.10**			**14.8%**	**3.4%**	**5.5%**	**6.1%**
		GRAND TOTAL OF TOP 50	**565.06**	**525.21**			**7.6%**	**4.2%**	**3.8%**	**4.1%**

a Revised. **b** tt = thousands of tons, bcf = billions of cubic feet, mp = millions of pounds, mg = millions of gallons. **c** Except refractory grade. **d** Synthetic and natural. **e** Original solution. **f** Primary solution. **g** All grades. **h** Includes both acid and ester, without double counting. **i** All forms. **j** 37% by weight. **k** Rubber grade. **l** Synthetic only. **m** High and low purity. **n** Solid and liquid. **Sources:** Bureau of the Census, Bureau of Mines, International Trade Commission, C&EN estimates

Plastics once again led polymer growth in 1979

	Billions of lb	Common units					Average annual growth			
	1979	1979	1978	1977	1974	1969	1978–79	1977–78	1974–79	1969–79
PLASTICS (millions of lb)										
Thermosetting resins	**4.86**	**4,857**	**4,488**	**3,943**	**3,494**	**2,852**	**8.2%**	**13.8%**	**6.8%**	**5.5%**
Phenolic and other tar acid resins	1.78	1,781	1,617	1,458	1,335	1,161	10.1	10.9	5.9	4.2
Polyesters (unsaturated)	1.15	1,147	1,209	1,061	911	688	−5.1	13.9	4.7	5.2
Urea resins	1.37	1,367	1,122	963	635	817	21.8	16.5	10.4	5.3
Epoxies (unmodified)	0.36	361	299	261	249	166	20.7	14.6	7.7	8.1
Melamine resins	0.20	200	202	200	164	b	−1.0	1.0	4.1	b
Thermoplastic resins	**28.08**	**28,083**	**25,186**	**22,753**	**20,852**	**12,955**	**11.5%**	**10.7%**	**6.3%**	**8.4%**
Low-density polyethylene	7.79	7,793	7,111	6,471	5,973	3,880	9.6	9.9	5.5	7.2
Polyvinyl chloride and copolymers	6.12	6,119	5,723	5,253	4,850	3,032	6.9	8.9	4.8	7.3
Polystyrene and copolymers	5.32	5,320	5,077	4,630	4,743	3,343	4.8	9.7	2.3	4.8
High-density polyethylene	5.01	5,010	4,201	3,652	2,837	1,610	19.3	15.0	12.1	12.0
Polypropylene and copolymers	3.84	3,841	3,074	2,747	2,249	1,090	25.0	11.9	11.3	13.4
TOTAL[a]	**32.94**	**32,940**	**29,674**	**26,698**	**24,146**	**15,807**	**11.0%**	**11.2%**	**6.4%**	**7.6%**
SYNTHETIC FIBERS (millions of lb)										
Cellulosics	**0.93**	**930**	**905**	**888**	**1,199**	**1,576**	**2.8%**	**1.9%**	**−5.0%**	**−5.1%**
Rayon	0.61	606	597	598	817	1,078	1.5	−0.2	−5.8	−5.6
Acetate	0.32	324	308	290	382	498	5.2	6.2	−3.2	−4.2
Noncellulosics	**9.43**	**9,431**	**8,696**	**8,098**	**6,909**	**4,029**	**8.5%**	**7.4%**	**6.4%**	**8.9%**
Polyester[c]	4.18	4,178	3,800	3,642	2,934	1,315	9.9	4.3	7.3	12.3
Nylon	2.72	2,721	2,550	2,326	2,126	1,411	6.7	9.6	5.1	6.8
Glass fiber	1.01	1,012	923	787	683	501	9.6	17.3	8.2	7.3
Acrylic[d]	0.76	761	726	709	634	533	4.6	2.4	3.7	3.6
Olefin[e]	0.76	759	692	634	531	269	9.7	9.1	7.4	10.9
TOTAL[a]	**10.36**	**10,361**	**9,601**	**8,986**	**8,108**	**5,605**	**7.9%**	**6.8%**	**5.0%**	**6.3%**
SYNTHETIC RUBBER (thousands of metric tons)										
Styrene-butadiene[f]	3.04	1,378	1,395	1,395	1,466	1,424	−1.2%	0.0%	−1.2%	−0.3%
Polybutadiene	0.88	397	377	361	310	268	5.3	4.4	5.1	4.0
Neoprene	0.40	183	161	165	163	204	13.7	−2.4	2.3	g
Ethylene-propylene	0.39	175	174	158	126	76	0.6	10.1	6.8	8.7
Butyl	0.43	194	154	149	164	132	26.0	3.4	3.4	3.9
Nitrile	0.17	75	73	70	88	70	2.7	4.3	−3.2	0.7
Other[h]	0.28	125	138	118	181	310[g]	−9.4	16.9	−7.1	0[g]
TOTAL	**5.57**	**2,527**	**2,472**	**2,416**	**2,498**	**2,285**	**2.2%**	**2.3%**	**0.2%**	**1.0%**

a Totals are only for those products listed. Totals may not add because of rounding. b Data on melamine and urea are combined for 1969. c Includes small amounts of anidex, saran, spandex, vinyon, and TFE-fluorocarbon yarn and monofilament. d Includes modacrylic. e Includes vinyon staple and tow. f Excludes high-styrene latex. g Data for neoprene and "other" are combined for 1969. h Includes polyisoprene, chlorosulfonated polyethylene, polyisobutylene, acrylic, fluoro, polysulfide, and silicone elastomers. Excludes polyurethane elastomers.
Sources: Society of the Plastics Industry, International Trade Commission, Textile Economics Bureau, Rubber Manufacturers Association, Bureau of the Census

manufacturing, of which they both are part. The broader index averaged 163.3 for 1979, an increase of 4.1% from 1978.

Last year, output increased for 42 of the Top 50 chemicals. In 1978, production had increased for just 37 of the chemicals. For only seven of the Top 50 did production decline last year from the year before, compared to 10 whose output declined in 1978 from 1977. Production was static for only one product in 1979—lime—compared to three the year before—sodium carbonate (soda ash), ethylene dichloride, and acetic anhydride.

Production of 17 of the chemicals increased more than 10% in 1979. In 1978, just 10 showed increases of 10% or more. Indeed, three chemicals on the list—toluene, urea, and terephthalic acid—had increases in output of more than 20% in 1979. In 1978, only urea and cumene output increased more than 20%, with cumene's 27.8% growth the greatest for that year.

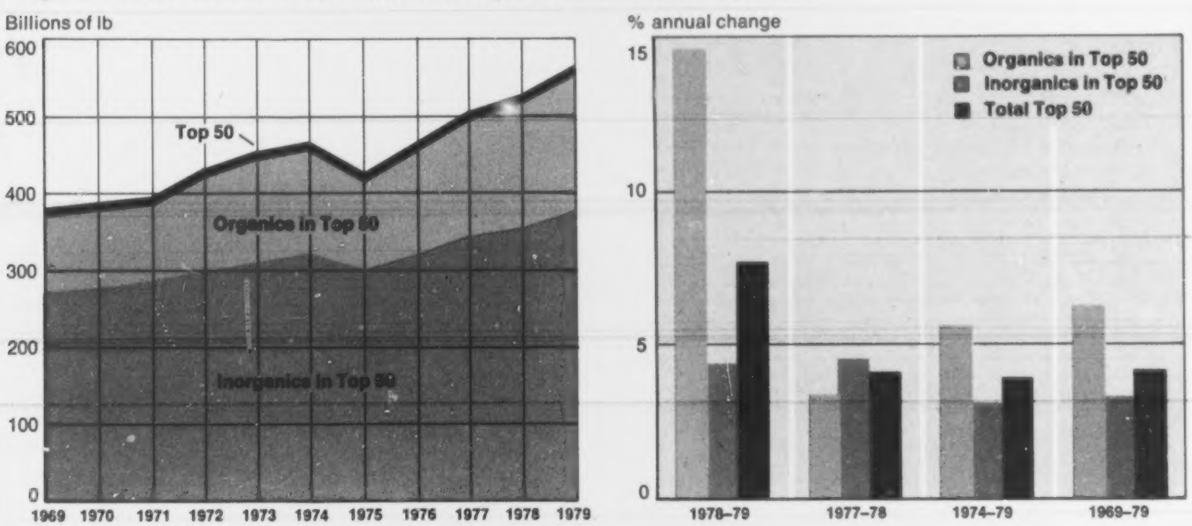
The biggest annual percentage growth in 1979 was for toluene, at 55.2%. The year before toluene production had declined 1.2%. Industry observers attribute much of last year's greater output to toluene's relatively new use as a blending agent to raise the octane rating of unleaded gasoline. As a result, toluene in 1979 moved to 16th place on the 1979 Top 50 list from 18th the year before. Toluene was also the largest gainer in terms of physical output. Production of toluene was 11.86 billion lb (1636 million gal) in 1979, a gain of 4.22 billion lb from 1978.

Production declines in 1979 were generally small compared to some registered in past years. The largest percentage decline was 5.3% for sodium sulfate. Most of the declines, however, for 1979 amounted to less than 1%. In 1978, all but two of the declines in production were greater than 1%, with the biggest loser being ammonium sulfate, off 11%.

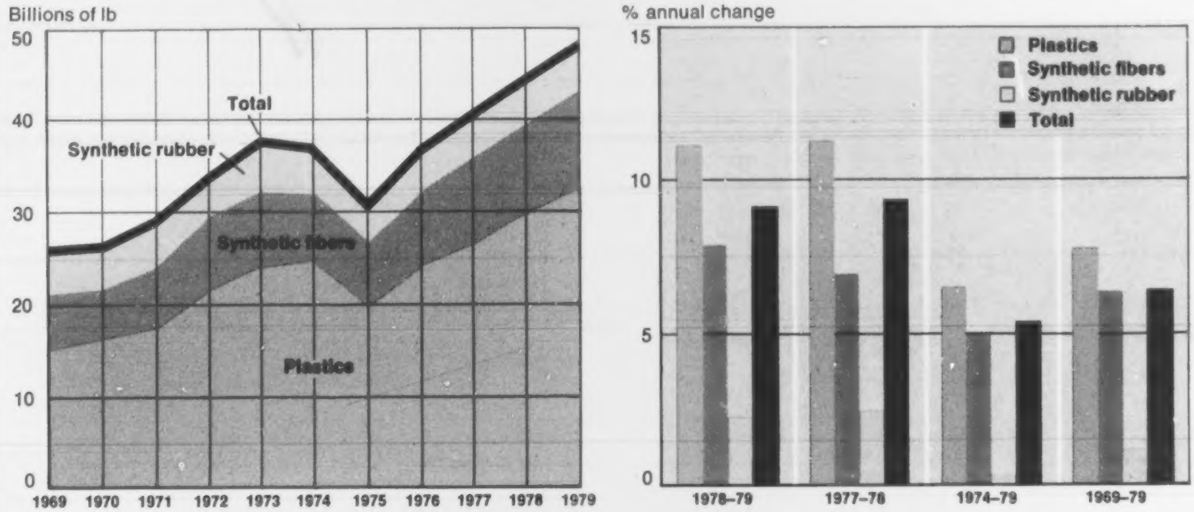
The biggest volume loser in 1979 was also sodium sulfate, with output off 140 million lb from 1978.

The biggest drop in rank last year was for ethylene dichloride, which fell to 17th place from 14th in 1978, in

Organics now account for a third of Top 50 chemicals output...



...thanks to two years of hefty growth for plastics



spite of a 7.5% increase in output for the year, as other products produced in about the same volume turned in much better advances.

Production of the basic chemicals—especially the organics—was spurred in 1979 by gains in production of downstream products, especially plastics.

Overall production of plastics increased 11.0% in 1979, slightly less than the increase of 11.2% scored in 1978. The difference is largely accounted for by smaller production gains for the thermosetting resins. Thermosets output gained 8.2% in 1979 from 1978, compared to a rise the year before of 13.8%. Thermoplastics did better in 1979, with output climbing 11.5% over 1978 production. In 1978, output of thermoplastics increased 10.7%. The biggest gainer for 1979 among the plastics was polypropylene, with a 25% increase in production.

Growth for synthetic fibers was better in 1979 than during the year before. Output increased 7.9%, compared to a 6.8% gain in 1978. Cellulosic fibers continued their lackluster performance, increasing just 2.8% over the year before. However, the noncellulosic fibers made up for this with an advance in production of 8.5% over 1978, paced by polyester with a 9.9% gain.

Synthetic rubber once again turned in a smaller growth rate than did the other polymeric products, with only a 2.2% production gain over 1978. In 1978, output had increased 2.3%. There were, however, two good gainers among the synthetic rubbers: Butyl rubber production increased 26% from 1978 and neoprene output climbed 13.7%.

After the very good year for chemical production in 1979, predictions for 1980 are anybody's guess. The consensus among economists is that there will be a recession this year which probably already has started. Just how long and how deep it will be is uncertain. Also uncertain is whether the recession will cause an actual decline in chemical production. The 1974–75 recession was the only postwar economic downturn during which chemical production actually declined year to year. □

50 C&EN's Top Fifty Chemical Producers

Rising prices spur sales of leading chemical producers

David M. Kiefer
C&EN, Washington

The heavy hand of inflation shows up clearly in the latest of C&EN's annual rankings of the 50 leading producers of chemicals in the U.S. All of the companies comprising C&EN's Top 50 group sold more chemicals last year than in 1978—with most of them tallying impressive gains. For the 50 as a whole, sales of chemical products totaled $90 billion. That's an increase of 25% from the previous year—and well more than double the amount just six years ago. It is also the greatest year-to-year increase since 1974, when sales jumped 40%.

As was the case five years earlier, though, the increase last year is more a reflection of higher selling prices than of increased physical volume of output. Production of basic chemicals and synthetic materials in the U.S. was up about 7% in 1979. But under the pressure of rising raw material and energy costs, prices of most chemical products rose strongly. Selling prices of industrial chemicals averaged about 17% higher for the year, according to the Bureau of Labor Statistics, and plastics prices rose 18% from 1978. Even so, prices of many chemicals produced in the U.S. compared favorably with those made overseas, so that sharply increased foreign business also bolstered the results turned in by U.S. firms. At the same time, expanded capacity and higher operating rates helped drive sales to a new high.

With oil prices rising inexorably throughout 1979, prices of petrochemicals and their derivatives, in particular, were forced upward. The result was a big gain in sales volume for their producers, especially the 14 oil refiners with a large stake in chemical markets who are among the Top 50. Exxon, for example, boosted its chemical sales 44% and moved up two levels in C&EN's Top 50 ranking into third place. Texaco, meanwhile, with an increase in chemical sales of 53% climbed nine places in the ranking to 28th. Phillips Petroleum and Atlantic Richfield, both of which scored a 52% advance in chemical sales last year, likewise moved several spots higher on the list.

All in all, the 14 petroleum companies among the Top 50 increased their sales of chemicals 40% in 1979. They now account for nearly 30% of the 50 companies' total chemical sales, compared with 25% in 1978.

The biggest increase in chemical sales for any of the Top 50, however, was chalked up by Tenneco. The big conglomerate has vaulted into 20th ranking in the compilation on the strength of an 82% increase in its chemical sales last year, following a 69% rise the year before. In 1977, the company was not ranked among the Top 50. Strong demand for Tenneco's chemical products gets only part of the credit for its higher sales, however. An even bigger factor during the past two years has been its consolidation of sales from its big British subsidiary, Albright & Wilson, since Tenneco acquired full ownership of that company in September 1978.

Another nonchemical company that has pushed its chemical sales up significantly is U.S. Steel. The leading steel producer brought seven major chemical projects, with a potential annual sales volume of about $350 million at current prices, on stream during 1979. U.S. Steel plowed $280 million into new chemical plant and equipment last year, four times what it invested in such projects only two years earlier, and its sales of chemicals have doubled since 1976.

But diversification works both ways. Although companies like Tenneco and U.S. Steel have been getting a bigger share of their sales dollar from chemicals, for a few of the old-line chemical producers ventures in other areas have trimmed the contribution of chemicals to their overall business. Last year, for instance, chemicals accounted for just 50% of Allied Chemical's total sales, down from 68% five years earlier. During the same period, Diamond Shamrock's sales of chemicals slipped to 52% from 65% of its total volume. Both companies now get a significantly greater proportion of their revenues from oil and gas operations.

Although their place in the rankings has changed in many cases, the producers included on 1979's Top 50 list are identical with the Top 50 of the year before. For the first time, all the companies on the list have chemical sales of more than $500 million. At least a few other U.S. producers sold more than $500 million worth of chemicals last year, as well. Cities Service, for one, rang up $527 in chemical volume. C&EN estimates, too, that both Goodyear Tire and ICI Americas, the U.S. subsidiary of Britain's Imperial Chemical Industries, probably sold $500 million or more, although neither discloses its chemical volume separately from other products.

In ranking the Top 50 chemical producers in terms of their chemical sales, C&EN defines "chemicals" to include industrial chemicals, plastics and resins, man-made fibers, synthetic rubber, fertilizers and pesticides, and various industrial specialty products. Excluded, as far as possible, are such related products as pharmaceuticals, coatings, fabricated plastics, detergents, chemical minerals such as sulfur or phosphate rock, and finished consumer items. Companies themselves, however, do not necessarily classify their chemical operations along these same lines. Therefore, the total "chemical" sales of one firm really may not be comparable with those reported by another. C&EN adjusts the data with its own estimates whenever possible to make them more consistent. Nevertheless, the rankings of the Top 50 should be considered as only approximate. □

Chemical sales top $1 billion for nearly two thirds of Top 50 chemical producers

Rank		Company	Chemical sales 1979 ($ millions)	Change from 1978	Total sales 1979 ($ millions)	Chemical sales as % of total sales	Industry classification	TOTAL COMPANY						
								Net income ($ millions)	Profit margin[b]			Return on stockholders' equity[c]		
									Per cent	Rank		Per cent	Rank	
1979	1978[a]								1979	1979	1978	1979	1979	1978
1	1	**Du Pont**	$9700	20%	$12,572	77%	Basic chemicals	$ 938.9	7.5%	13	10	18.0%	14	9
2	2	**Dow Chemical**	6634	33	9,255	72	Basic chemicals	783.9	8.5	7	8	20.1	7	6
3	5	**Exxon**	5807	44	79,106	7	Petroleum	4295.2	5.4	29	32	19.0	11	19
4	3	**Union Carbide**	5300[d]	14	9,177	58	Basic chemicals	556.2	6.1	22	23	13.8	34	35
5	4	**Monsanto**	5215	21	6,193	84	Basic chemicals	331.0	5.3	30	16	11.9	40	32
6	7	**Celanese**	3010	23	3,146	96	Basic chemicals	141	4.5	37	35	13.6	36	31
7	6	**W. R. Grace**	2619[d]	2	5,267	50	Specialty chemicals	222.6	4.2	38	37	14.2	33	29
8	8	**Shell Oil**	2599	37	14,431	18	Petroleum	1125.6	7.8	11	11	16.1	23	23
9	11	**Gulf Oil**	2437[d]	43	23,910	10	Petroleum	1322	5.5	28	34	15.2	28	39
10	9	**Allied Chemical**	2150	16	4,332	50	Basic chemicals	175.6	4.1	39	22	14.3	32	30
11	10	**Hercules**	2039	19	2,345	87	Basic chemicals	172.5	7.4	14	20	18.2	13	26
12	12	**Occidental Petroleum**	1994[d]	20	9,555	21	Petroleum	561.6	5.9	26	49	33.0	1	48
13	15	**Standard Oil (Ind.)**	1958	50	18,610	11	Petroleum	1506.6	8.1	9	13	18.0	15	14
14	20	**Phillips Petroleum**	1693	52	9,503	20	Petroleum	891.1	9.4	5	5	20.9	6	4
15	13	**American Cyanamid**	1685[d]	16	3,187	53	Basic chemicals	168.5	5.3	31	19	12.5	39	28
16	21	**Atlantic Richfield**	1662	52	16,234	10	Petroleum	1165.9	7.2	15	14	19.1	10	12
17	14	**Eastman Kodak**	1576	17	8,028	20	Photographic equipment	1000.8	12.5	2	2	18.6	12	5
18	16	**Stauffer Chemical**	1496	15	1,526	98	Basic chemicals	136.0	8.9	6	6	16.0	25	8
19	19	**Rohm & Haas**	1479	30	1,590	93	Basic chemicals	95.5	6.0	23	31	15.0	29	38
20	31	**Tenneco**	1470[d]	82	11,209	13	Petroleum	571	5.1	32	21	15.4	26	17
21	17	**Borden**	1454[d]	16	4,313	34	Dairy products	134.0	3.1	42	38	11.3	41	25
22	18	**Ethyl Corp.**	1440[d]	17	1,657	87	Basic chemicals	97.5	5.9	25	17	16.1	24	13
23	23	**Mobil**	1325	32	44,721	3	Petroleum	2007.2	4.5	36	39	19.1	9	27
24	22	**Diamond Shamrock**	1234	23	2,357	52	Basic chemicals	178.1	7.6	12	9	17.5	17	11
25	33	**U.S. Steel**	1207	58	12,929	9	Steel	(293.0)[e]	—	—	—	—	—	—
26	24	**FMC**	1135	14	3,307	34	Farm and construction machinery	151.6	4.6	35	26	13.1	38	21
27	25	**Air Products[f]**	1062	16	1,230	86	Basic chemicals	97.5	7.9	10	12	17.2	18	10
28	37	**Texaco**	1047	53	38,350	3	Petroleum	1759.1	4.6	34	41	16.5	21	42
29	30	**BASF Wyandotte**	1045	28	1,103	95	Basic chemicals	9.7	0.9	48	40	3.7	47	36
30	29	**Standard Oil of Calif.**	1043	26	29,948	3	Petroleum	1784.7	6.0	24	28	19.2	8	20
31	28	**B. F. Goodrich**	1041	21	2,988	35	Rubber products	82.6	2.8	44	42	9.2	44	43
32	26	**Ashland Oil**	1017	15	6,474	16	Petroleum	186.4	2.9	43	45	17.5	16	40
33	27	**PPG Industries**	972	10	3,092	31	Glass products	218.9	7.1	16	27	16.4	22	34
34	38	**American Hoechst**	968	42	1,174	82	Basic chemicals	30	2.6	45	45	na	—	—
35	32	**Mobay Chemical**	955	23	955	100	Basic chemicals	58.1	6.1	21	30	16.8	20	24
36	39	**Union Oil of Calif.**	865	28	7,568	11	Petroleum	500.6	6.6	17	15	16.9	19	15
37	41	**Ciba-Geigy**	844	27	1,320	64	Specialty chemicals	na	na	—	—	na	—	—
38	42	**Williams Cos.**	840	27	1,850	49	Agricultural chemicals	69.5	3.8	41	48	9.3	43	47
39	34	**Olin**	823	15	1,778	46	Basic chemicals	71.2	4.0	40	36	9.6	42	41
40	35	**Reichhold Chemicals**	794	14	875	91	Basic chemicals	12.2	1.4	47	47	6.2	46	45
41	42	**Conoco**	792	32	12,648	6	Petroleum	815.4	6.3	19	29	21.6	5	16
42	36	**International Minerals[g]**	780	12	1,475	53	Agricultural chemicals	120.8	8.2	8	7	15.3	27	7
43	40	**National Distillers**	773	16	2,115	37	Alcoholic beverages	135.8	6.4	18	24	13.3	37	37
44	44	**Lubrizol**	725	24	725	100	Specialty chemicals	90.8	12.5	1	1	24.2	2	2
45	48	**Dow Corning**	610	27	610	100	Specialty chemicals	71.5	11.7	3	3	21.8	4	3
46	50	**Borg-Warner**	595	26	2,717	22	Automobile equipment	155.6	5.7	27	18	14.4	31	18
47	49	**Nalco Chemical**	579	22	579	100	Specialty chemicals	63.3	10.9	4	4	24.2	3	1
48	46	**Akzona**	576	11	1,012	57	Basic chemicals	25.6	2.5	46	43	7.9	45	44
49	47	**Pennwalt**	562	17	1,079	52	Basic chemicals	50.0	4.6	33	25	13.7	35	22
50	45	**NL Industries**	537	1	1,810	30	Basic chemicals	114.6	6.3	20	33	14.7	30	33

a Revised. **b** Net income as a percentage of net sales. **c** Net income as a percentage of net worth. **d** Chemical sales include significant amounts of nonchemical products, such as fabricated plastics, coatings, metals, minerals, and the like. **e** Deficit. **f** For the year ended Sept. 30. **g** For the year ended June 30. **na** = not available. **Note:** Industry classifications are based largely, but not entirely, on the federal Enterprise Standard Industrial Classification system.

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NEWS

Chemical company earnings, profit margins both increase in first quarter
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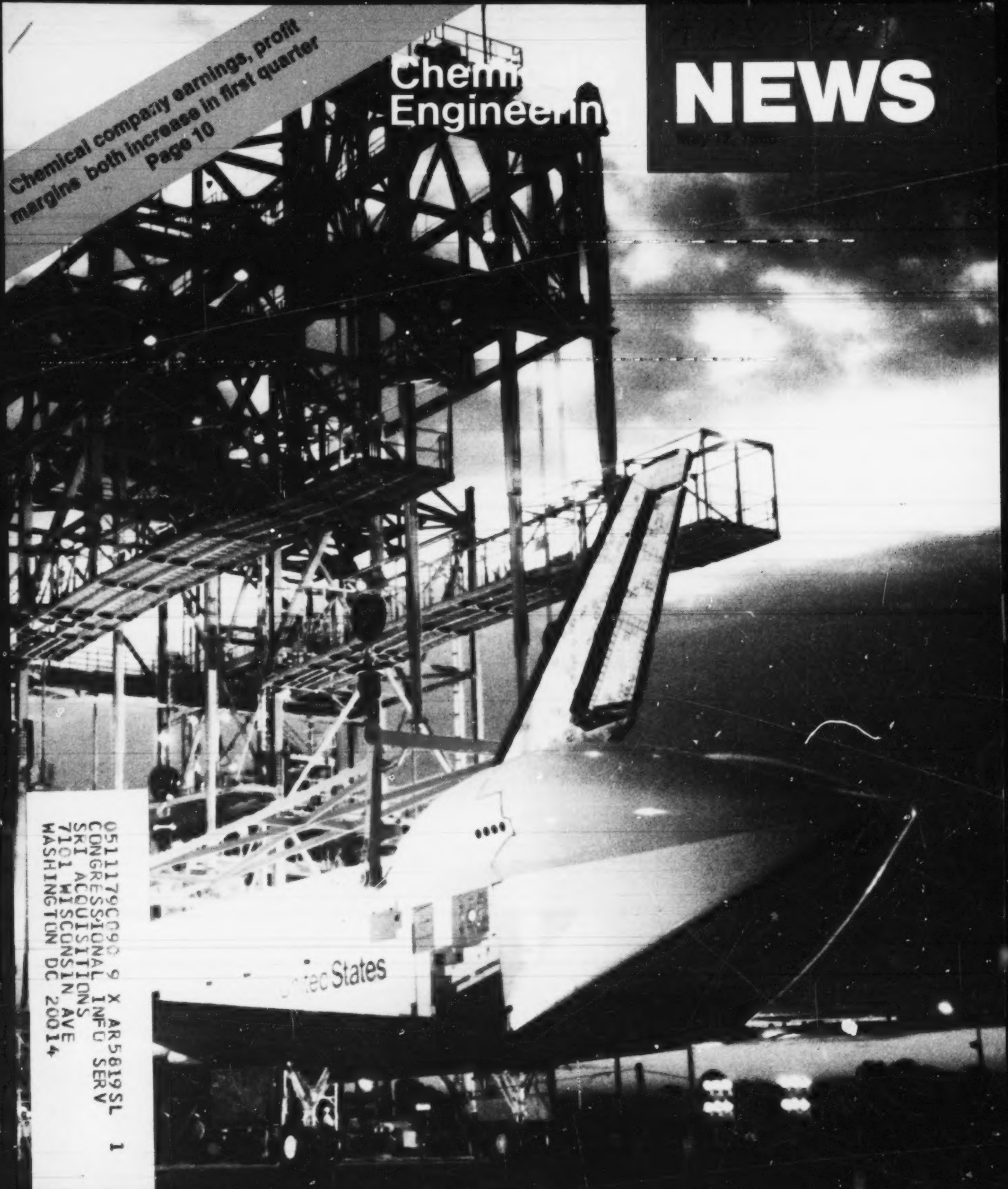

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Space Shuttle

The problem with the tiles Page 27

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Cover: Space shuttle *Columbia* is lowered to apron at Kennedy Space Center's shuttle landing facility by device used to mount and remove shuttle orbiters from NASA's 747 carrier aircraft

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News of the Week

- ***EPA issues regulations*** *to identify hazardous wastes; sets standards for treatment, storage, and disposal facilities.* ***Page 4***
- ***Coalition of Vietnam veterans groups*** *files suit to block Veterans Administration study of agent orange.* ***Page 5***
- ***High-pressure tests*** *duplicate the extreme pressures in Earth's interior to study how mantle, core layers formed.* ***Page 5***
- ***$80 million research lab*** *planned by International Harvester will employ 200 scientists and engineers.* ***Page 5***
- ***April was the cruelest month*** *for business since 1974 recession; volume and consumer buying intentions dropped.* ***Page 6***
- ***Tandem Mirror Experiment*** *for confining fusion plasma, at Lawrence Livermore Laboratory, is promising.* ***Page 6***

Business

- ***Profit margins*** *of U.S. basic chemical firms increased in first quarter.* ***Page 10***

International

- ***Canada's top chemical firms*** *had good first quarter but strong recovery begun last year is losing steam.* ***Page 17***

Government

- ***Environmentalists fear*** *that Sen. Muskie's advance to the Cabinet will affect their movement adversely.* ***Page 19***
- ***Strife-ridden OTA faces another crisis*** *as Congressmen critical of the agency threaten to ax it from the budget.* ***Page 21***

Education

- ***Four-month trial*** *finds Prof. Solomons not guilty of plagiarizing Morrison and Boyd in "Organic Chemistry."* ***Page 23***
- ***Workshop on teaching chemistry to the physically handicapped*** *will lead to preparation of ACS guidelines manual.* ***Page 24***

Science

- ***Resonance Raman spectroscopy*** *on a picosecond time scale made possible by using short pulsed lasers.* ***Page 24***

AIC Award

- ***Arthur M. Bueche,*** *winner of AIC's gold medal, who reorganized research at General Electric, has become a statesman of science and technology.* ***Page 25***

Technology

- ***Problems of bonding*** *of space shuttle tiles that protect from heat of re-entry are focus of efforts by Rockwell International and NASA engineers.* ***Page 27***

Books

- ***Carl Djerassi claims politics,*** *not science, shapes future of birth control—threatened by federal cuts.* ***Page 31***

Profit margins rebound in first quarter

A 31% earnings increase and a 21% sales jump combined to drive up first-quarter profit margin to 7.2% for U.S. basic chemical firms

William F. Fallwell
and William J. Storck
C&EN, New York

Good fortune continued for chemical companies, oil firms, and other U.S. chemical producers in the first quarter of 1980. For the sixth quarter in a row, the average earnings gain for 39 of C&EN's list of 40 chemical companies topped 25%. For five of these past six quarters, including the most recent one, average earnings rose 30% or more.

The average gain in sales for 39 companies reporting results by press time was 21%. This is the fifth straight quarter in which sales increased 20% or more from the year-earlier quarter.

Most of the sales increase for the first quarter can be attributed to price increases. According to the Department of Commerce's Producer Price Index, prices for chemicals and allied products increased 19.9% in the first quarter from first-quarter 1979. Thus, little of the chemical firms' sales increase was in output gains.

Production of chemicals and allied products for the first quarter was 4.6% ahead of last year, according to the Federal Reserve Board. For the more narrow basic chemical category, production increased only 2%.

Earnings coverage again expanded

C&EN continues to expand the coverage of chemical industry performance. For the first time, this quarterly wrapup of chemical company earnings includes a 12-month running profit margin. This is after-tax earnings as a percentage of sales for the 12 months ending in the current quarter. Now readers not only can compare profitability for the current quarter with that for the comparable year-earlier quarter but compare the current quarter with the average for the past year and compare the year just ending with that preceding it.

In addition, for the first time, extraordinary items and nonrecurring items for each company are included in footnotes. Previously, these items also had been excluded from the earnings tabulations, but were not cited elsewhere.

Finally, C&EN has broadened its definition of a basic chemical company to reflect the chemical industry more completely. A company must now have 40% or more of its total sales in chemicals, and these chemical sales must be larger than any other division sales.

Chemical industry leaders for first-quarter 1980

Sales			Earnings		Profitability	
Rank		$ Millions		$ Millions[a]	Earnings as % of sales	
1	Du Pont	$3567.9	Du Pont	$244.4	Texasgulf	26.3%
2	Dow Chemical	2809.5	Dow Chemical	230.5	Freeport Minerals	22.6
3	Union Carbide	2565.6	Union Carbide	219.9	International Flavors	14.9
4	Monsanto	1822.5	Monsanto	164.2	Beker Insustries	14.5
5	Allied Chemical	1384.2	Texasgulf	73.6	Big Three Indsustries	13.3
6	W. R. Grace	1362.0	Stauffer Chemical	69.6	Lubrizol	13.0
7	Celanese	847.0	Allied Chemical	68.3	Loctite	12.4
8	American Cyanamid	830.0	Diamond Shamrock	56.3	Stauffer Chemical	11.9
9	PPG Industries	797.4	PPG Industries	54.7	Nalco Chemical	11.0
10	B. F. Goodrich	767.5	W. R. Grace	48.0	First Mississippi	10.7

[a] After taxes. **Note:** For 40 chemical companies listed on page 12.

However, one problem has apparently moderated, at least for this quarter. The cost-price squeeze, so much on producers' minds in the fourth quarter, apparently lessened somewhat, since the profits gain so far outstripped the sales increase during the first three months of 1980.

Nevertheless, many of the larger chemical companies still were not able to pass through cost increases entirely in proportionate product price increases. Edward G. Jefferson, president of industry sales leader Du Pont, says, "It has not been feasible to increase selling prices sufficiently to offset the very sharp rise in costs of energy, petrochemical raw materials, and precious metals." Thus, Du Pont's profit margin slipped to 6.9% for the first quarter, compared to 8.4% for first-quarter 1979. According to Jefferson, the cost of petrochemical raw materials was up 66% compared with the first quarter last year.

A similar case prevails at the second largest chemical company, Dow Chemical. Dow financial vice president G. J. Williams says the price increases on the company's products during the quarter "were significant as we attempted to offset the continuing escalation of the cost of hydrocarbons and energy." Williams adds, "Despite these increases, costs rose faster than our prices, and our profit margin slipped as a result." Dow has little to complain about, though. Its first-quarter profit margin of 8.2% is still well ahead of the industry average of 7.2%, and the slippage is slight from the 8.5% profit margin Dow achieved in first-quarter 1979. PPG Industries chairman L. Stanton Williams says, "In general, high inflation is producing rapid rises in our costs, making it difficult to maintain profit margins." However, PPG did keep its profit margin at 6.9%, as it was a year ago.

More typical, however, were other companies that stayed ahead of the cost squeeze. For example, Union Carbide's profit margin rose to 8.5% from 7.1% in first-quarter 1979, Diamond Shamrock's increased to 7.5% from 5.8%, and International Minerals' jumped to 10.2% from 8.7%.

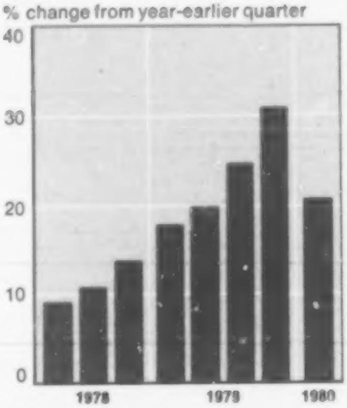
Business outside the U.S. continued to help earnings for many of the chemical companies in the first

Chemical Industry First-Quarter Results

- **Sales gains slowed**
- **Earnings were up 31%**
- **Profit margins recovered**
- **Production increased 4.6%**
- **Prices climbed 20%**

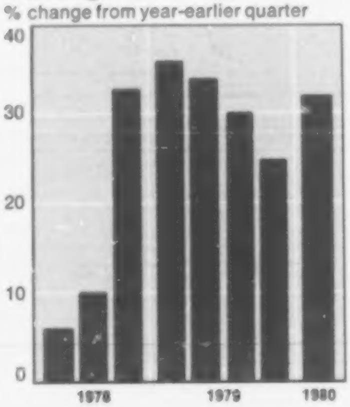
Sales

% change from year-earlier quarter



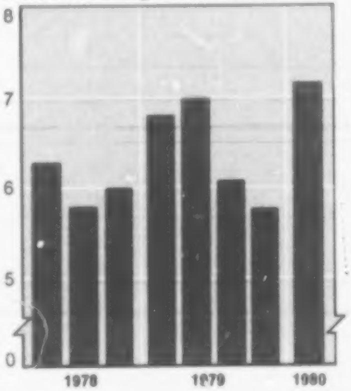
Earnings

% change from year-earlier quarter



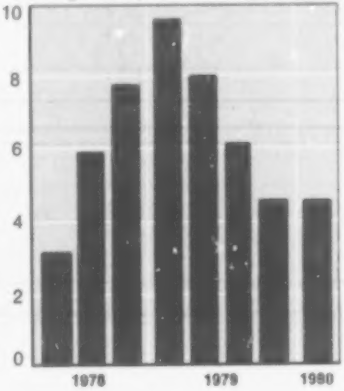
Profit margins

After-tax earnings as % of sales



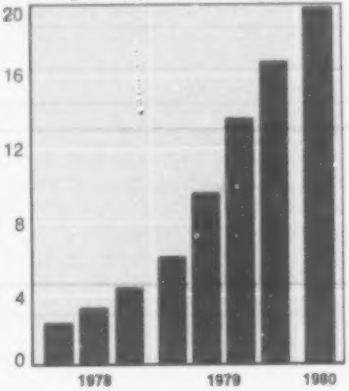
Production

% change from year-earlier quarter



Prices

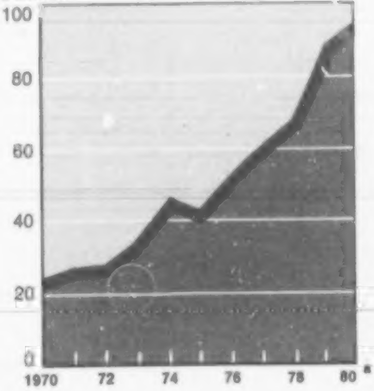
% change from year-earlier quarter



For full year, sales likely will rise 10% to top $97 billion, but recession probably will flatten earnings at $5.7 billion and profit margins will fall to about 5.9%

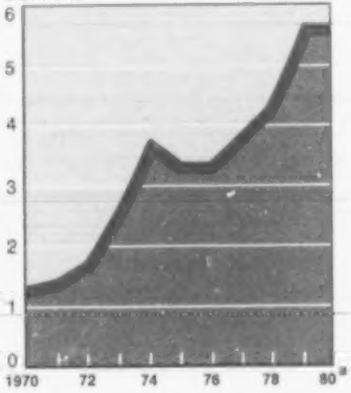
Annual sales

$ Billions



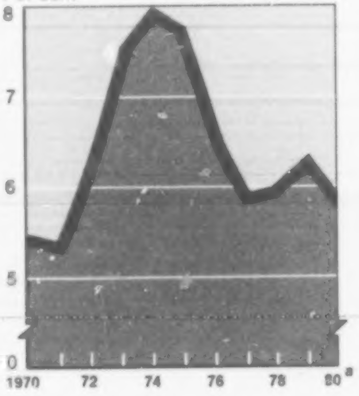
Annual earnings

$ Billions



Annual profit margins

Per cent



[a] C&EN estimates. **Note:** All sales, earnings, and profit margin data are based on the combined performance of the 40 largest chemical makers listed on page 12.

First-quarter earnings rose 32%, bringing profit margins up to 7.2%

	FIRST-QUARTER 1980						12-Month profit margin[b]		Earnings per share[c]	
	Sales	Earnings	Change from 1979		Profit margin[a]					
	($ millions)		Sales	Earnings	1980	1979	1980	1979	1st qtr	Recent 12 months
Du Pont	$3,567.9	$244.4	18%	−2%	6.9%	8.2%	7.1%	7.8%	$1.66	$6.52
Dow Chemical	2,809.5	230.5	35	31	8.2	8.5	8.4	8.5	1.27	4.35
Union Carbide[e]	2,565.6	219.9	19	44	8.5	7.1	—	—	3.32	11.00
Monsanto	1,822.5	164.2	12	1	9.0	10.0	6.4	6.1	4.49	10.08
Allied Chemical	1,384.2	68.3	64	85	4.9	4.3	4.2	4.8	2.06	6.55
W. R. Grace[f]	1,362.0	48.0	17	26	3.5	4.9	4.5	3.9	1.01	4.88
Celanese	847.0	36.0	14	13	4.3	4.3	4.5	4.5	2.39	9.67
American Cyanamid	830.0	38.0	10	−7	4.6	5.4	5.1	5.6	0.79	3.39
PPG Industries	797.4	54.7	10	10	6.9	6.9	7.1	6.8	1.67	6.89
B. F. Goodrich	767.5	20.3	7	−23	2.6	3.7	2.4	3.0	1.20	4.21
Diamond Shamrock	755.3	56.3	50	91	7.5	5.6	7.9	7.8	1.06	3.87
Hercules	646.0	33.7	16	−7	5.2	6.5	5.8	6.1	0.76	3.20
Stauffer	582.9	69.6	17	12	11.9	12.5	8.9	9.7	1.59	3.19
National Distillers	558.5	43.1	2	35	7.7	5.8	6.9	6.0	1.27	3.84
Williams Cos.	479.3	35.1	14	374	7.3	1.8	5.1	2.4	1.29	3.57
Olin	475.2	22.1	9	26	4.7	4.0	4.2	4.6	0.92	3.21
International Minerals[g]	459.5	47.0	23	44	10.2	8.7	8.7	8.1	2.16	6.11
Ethyl Corp.[h]	438.6	21.2	18	—	4.9	5.7	5.7	6.1	1.03	4.77
Rohm & Haas[i]	435.7	27.1	13	11	6.2	6.4	6.0	5.1	2.10	7.59
Cabot	433.8	32.3	58	80	7.4	6.5	6.9	6.5	3.09	9.27
Air Products	378.0	34.2	26	40	9.1	8.2	8.3	7.6	1.21	3.97
Pennwalt	302.8	12.3	17	23	4.1	3.9	4.7	4.6	1.20	5.21
Akzona	293.2	5.3	13	−43	1.8	3.6	2.7	2.5	0.43	1.66
Witco Chemical	285.6	10.5	29	12	3.7	4.2	4.3	4.5	1.08	4.56
Texasgulf	280.0	73.6	61	191	26.3	14.5	20.7	10.0	1.97	4.82
Reichhold Chemicals	236.3	4.2	16	62	1.8	1.3	1.5	1.8	0.50	1.57
Lubrizol	223.2	29.0	39	65	13.0	10.9	12.7	12.7	1.49	5.25
Ferro	169.5	7.0	24	1	4.1	5.1	5.0	5.5	0.92	4.08
Nalco Chemical	147.4	16.2	8	6	11.0	11.2	10.9	11.4	0.81	3.03
Freeport Minerals	156.4	35.3	48	75	22.6	19.2	21.6	13.1	1.12	4.89
Thiokol	155.0	9.9	14	22	6.4	6.0	7.3	5.5	1.71	6.57
Big Three Industries	152.9	20.4	26	38	13.3	12.2	12.6	12.9	1.01	3.40
Liquid Air[j]	—	—	—	—	—	6.4	—	5.9	—	—
International Flavors	121.8	18.2	20	17	14.9	15.3	14.9	15.4	0.50	1.75
Mallinckrodt	112.0	9.0	14	16	8.0	7.9	8.2	7.7	0.92	3.47
Beker Industries[k]	74.5	10.8	52	1250	14.5	1.6	9.1	l	0.93	1.98
Crompton & Knowles	61.8	2.1	3	l	3.5	3.5	3.3	2.8	0.90	3.42
Petrolite	59.5	5.1	39	34	8.6	8.9	8.3	9.2	0.87	2.87
Loctite	50.7	6.3	24	7	12.4	14.2	13.6	14.9	0.64	2.59
First Mississippi	42.1	4.5	17	124	10.7	5.5	13.7	11.7	0.52	2.01
Total 20 largest companies[m]	**$22,018.4**	**$1511.8**	**21.0%**	**22.5%**	**6.9%**	**6.8%**	**6.3%**	**6.3%**		
Total 19 other companies[m]	**$3,303.2**	**$313.9**	**22.0%**	**61.5%**	**9.5%**	**7.0%**	**8.5%**	**6.7%**		
GRAND TOTAL[m]	**$25,321.6**	**$1825.7**	**21.1%**	**31.7%**	**7.2%**	**6.8%**	**6.6%**	**6.4%**		

a After-tax income as percentage of sales. b After-tax income as percentage of sales for 12 months ending first-quarter 1980 and 1979. c Fully diluted before nonrecurring items and extraordinary charges for continuing operations. d As of April 30. e Union Carbide had a $217.3 million gain for accounting changes during the first quarter. Since previous quarters were not restated, 12-month profit margins are not comparable. 12-Month earnings per share for Union Carbide are approximate. f Excludes an additional net gain of $17.1 million from divestments. g Excludes $7.9 million loss on disposal of certain chemical businesses. h Excludes $7.3 million gain on disposal of land. I Excludes

quarter. For instance, Diamond Shamrock chairman W. H. Bricker says exports continued to provide support for plastics, industrial chemicals, and agri chemicals.

Similarly, Dow's largest regional sales increase was a 50% gain in Europe. Union Carbide's total international sales increased 20%, and exports gained 23% compared to the first quarter last year.

Du Pont's Jefferson says the company's international business continued to post strong sales growth with gains in all geographic areas. The company's total sales outside the U.S. were $1.2 billion in the first quarter, 28% more than in the same period last year.

Almost to a company, however, chemical firms are concerned about the remainder of 1980. PPG's Williams says, "Auto [output] and housing starts were off substantially for the quarter and we see other signs of the early stages of a recession."

Kenneth E. Davis, the new president and chief operating officer at Stauffer Chemical, says some expected market downturn could prevent a strong performance for the company in the second and third quarters. However, he adds that the

STOCK MARKET DATA

Stock price[d] April 30	Recent 12 months High	Low	Price-earnings ratio April 30	Annual indicated dividend	Dividend yield, % of price
36½	45⅞	31⅛	6	$2.00	5.5%
32½	39¼	24¾	7	1.60	4.9
38¼	47⅞	35¼	4	3.00	7.8
46¼	62¾	42¼	5	3.60	7.8
47¼	61⅜	30¼	7	2.20	4.7
34⅛	44½	27	7	2.05	6.0
45	50	39¾	5	3.60	8.0
26	38	20⅝	8	1.60	6.2
29⅜	34¼	26⅛	4	2.16	7.4
18⅝	24	16⅜	4	1.56	8.4
28¼	36¾	20¼	7	1.60	5.7
17½	24⅝	15⅛	5	1.20	6.9
16¾	25	14½	5	1.20	7.2
26½	32½	20¾	6	2.00	7.5
31	40½	17¼	9	1.10	3.5
16	25	12½	5	1.00	6.3
34⅜	34⅜	33¼	6	2.32	6.7
25	30½	22¼	5	1.50	6.0
37⅛	48½	32¾	5	2.00	5.4
60⅝	68⅝	34⅝	7	2.00	3.3
38	43⅛	26½	10	0.80	2.1
26¼	35⅞	25⅜	5	2.20	8.4
9⅞	17½	7¾	6	0.80	8.1
22¼	33	20¼	5	1.40	6.3
35⅞	53⅝	21⅛	7	1.60	4.5
11⅛	16½	9⅝	7	0.74	6.7
58⅜	64½	42½	11	1.80	3.1
20⅛	26	17	5	1.20	6.0
32	35⅝	27¾	10	1.60	5.0
36½	49¾	31½	10	1.00	2.7
49¼	58	33½	7	1.55	3.1
46	47¾	34¾	15	0.88	1.9
20¼	28¾	20	8	1.40	6.9
19¼	23	16⅝	11	0.80	4.2
30¼	33¼	25¼	9	1.20	4.0
11⅝	16	6	5	—	—
20	22¼	14	6	1.20	6.0
44½	52½	35¼	16	1.24	2.8
28½	45	25½	11	0.56	2.0
29¼	37¾	12½	14	0.50	1.7

$3.7 million gain in first-quarter 1979 on income tax loss carry-forwards. j Not all data available by press time. k Excludes $19 million gain in first-quarter 1979 on sale of 50% interest in certain assets. l Deficit. m Averages except for sales and earnings.

fourth quarter probably will be good because of international sales of agricultural products and improved performance of plastics operations. Stauffer chairman H. Barclay Morley says the company's earnings will be flat or slightly up for the year unless the economy goes into a severe recession in the second and third quarters.

The weakening of the economy is already being felt by companies with large sales to the automotive and home-building industries. As is traditional, fibers seem to be the first and worst hit. At Celanese, income from fibers dropped 37% to 61 cents a share in the first quarter from 97 cents a share in the first quarter last year. This decline was in polyester and nylon manufactured in the U.S., which lost 11 cents a share in the first

Ground rules for the C&EN earnings analysis

C&EN's quarterly report on financial performance of the U.S. chemical industry contains data from the 40 largest U.S. basic chemical companies and from 50 diversified companies, each with more than $200 million in annual chemical sales.

The 40 largest chemical firms included in the table on this page produce 50 to 60% of chemicals sold in the U.S. The table of nonchemical firms on pages 14 and 15 is divided into two groups. The first includes 20 oil and gas companies specializing in basic petrochemicals. The second is major diversified firms with large chemical operations. In both cases, chemical sales are more than $200 million annually.

Also included is a state-of-the-industry page. These graphs give quarterly comparisons for the past two years on five specific measures for the 40 largest chemical firms, plus annual data for the past decade for the same group.

In referring to chemical sales, C&EN means those chemicals whose molecular composition has been changed in the course of manufacture. Hence, chemical sales include those of traditional categories of basic petrochemicals and inorganics; organic intermediates and inorganic compounds; polymers such as plastics and fibers; agricultural chemicals; and specialty derivatives. The list does not include companies whose primary business is formulating or fabricating products made from purchased process chemicals. By the government's Standard Industrial Classification code, the survey's chemicals would fall into SIC categories 281, 282, 286, 287, and, in part, 289.

In listing earnings the survey gives after-tax income for continuing operations before nonrecurring items and extraordinary charges. Foreign currency translations are included. Earnings per share are given with full dilution for convertible issues of securities. For companies with fiscal years different from the calendar year, data are given for the most recent quarter.

In other definitions, profit margin is after-tax earnings as a percentage of net sales. The 12-month indicated dividend is the company's latest announced quarterly dividend multiplied by four with year-enders. Price/earnings multiples are for trailing 12-month earnings per share.

Twelve-month earnings per share are for the year ending with the latest quarter. Yield is the indicated annual dividend as a percentage of latest stock price. Shares outstanding are companies' figures, generally averages for latest quarter.

Earnings and profit margins also jump for oil and other diversified chemical producers

	Chemical sales as % of total sales	FIRST-QUARTER 1980						STOCK MARKET DATA			
		Total sales	Earnings	Change from 1979		Profit margin[a]		Earnings per share		Stock price	
		($ millions)		Sales	Earnings	1980	1979	1st qtr	Recent 12 months	April 30	12-Month high
OIL AND GAS COMPANIES											
Exxon	8%	$27,649.0	$1,925.0	47%	102%	7.0%	5.1%	$4.40	$11.98	$60\frac{3}{4}$	$67\frac{3}{4}$
Mobil[b]	3	15,276.0	922.0	47	105	6.0	4.3	4.34	11.70	$72\frac{3}{4}$	$89\frac{1}{2}$
Texaco[b]	3	13,249.0	600.6	59	98	4.5	3.6	2.21	7.58	$35\frac{3}{8}$	$41\frac{5}{8}$
Standard Oil of California	3	10,447.0	627.0	50	83	6.0	4.9	3.67	12.10	$70\frac{3}{4}$	85
Gulf Oil	9	7,756.0	389.0	39	56	5.0	4.5	1.99	7.49	$40\frac{1}{8}$	$54\frac{1}{2}$
Standard Oil (Ind.)	11	6,452.0	576.0	47	65	8.9	8.1	3.91	11.75	$102\frac{1}{8}$	$121\frac{1}{4}$
Atlantic Richfield	10	5,433.8	426.1	55	76	7.8	6.9	3.45	9.81	$91\frac{3}{4}$	106
Shell Oil	18	4,798.0	373.0	56	67	7.8	7.3	2.42	8.27	$67\frac{5}{8}$	76
Conoco	6	4,300.0	328.6	54	103	7.6	5.8	3.05	9.13	$47\frac{1}{8}$	$58\frac{5}{8}$
Phillips Petroleum	20	3,380.0	338.6	70	91	10.0	8.9	2.20	6.82	$42\frac{5}{8}$	$61\frac{1}{8}$
Occidental Petroleum	18	3,346.6	277.9	82	226	8.3	4.5	3.37	9.07	$23\frac{5}{8}$	$31\frac{7}{8}$
Tenneco	13	3,316.0	178.0	36	45	5.4	5.0	1.61	5.66	$34\frac{5}{8}$	$45\frac{1}{2}$
Sun Co.	3	3,100.0	251.3	29	96	8.1	5.4	3.99	13.09	69	$88\frac{3}{8}$
Standard Oil (Ohio)	5	2,500.0	450.7	47	169	18.0	15.7	3.67	12.11	93	$110\frac{1}{2}$
Union Oil	11	2,380.0	152.9	35	34	6.4	6.5	1.76	6.22	$50\frac{3}{8}$	$62\frac{1}{2}$
Cities Service	9	2,172.0	170.1	50	117	7.8	5.4	6.13	15.84	$93\frac{7}{8}$	$112\frac{1}{2}$
Ashland Oil[b]	16	2,000.0	47.4	33	55	2.4	2.0	1.59	6.47	33	$45\frac{1}{2}$
El Paso	11	1,028.4	34.7	84	11	3.4	5.6	0.74	3.04	$17\frac{5}{8}$	$30\frac{1}{2}$
Kerr-McGee	16	780.4	47.1	30	41	6.0	5.6	1.82	6.71	$68\frac{1}{4}$	$78\frac{5}{8}$
American Petrofina	19	523.4	31.4	51	176	6.0	3.3	2.92	9.63	$38\frac{1}{2}$	$48\frac{1}{4}$
DIVERSIFIED MANUFACTURERS											
Engelhard Minerals	1	5,934.6	141.4	110	198	2.4	1.7	2.05	6.43	$28\frac{3}{4}$	$38\frac{3}{4}$
General Electric	2	5,880.0	341.5	16	13	5.8	6.0	1.50	6.37	$47\frac{1}{2}$	$57\frac{1}{2}$
U.S. Steel[b]	9	3,200.0	101.2	3	116	3.2	1.5	1.16	c	19	$24\frac{1}{2}$
Procter & Gamble	4	2,790.0	189.2	14	12	6.8	6.9	2.29	8.16	$71\frac{1}{2}$	$80\frac{3}{4}$
Eastman Kodak	20	2,137.1	215.9	30	9	10.1	12.0	1.34	6.32	$52\frac{5}{8}$	$63\frac{1}{2}$
Goodyear Tire	6	2,023.4	50.7	1	−6	2.5	2.7	0.70	1.98	12	$17\frac{3}{4}$
Esmark	8	1,652.7	21.4	7	24	1.3	1.1	0.93	4.52	$25\frac{7}{8}$	$35\frac{1}{2}$
3M	15	1,494.0	167.3	14	10	11.2	11.7	1.43	5.72	$52\frac{3}{4}$	$58\frac{1}{4}$
Aluminum Co. of America	5	1,303.0	143.5	8	12	11.0	10.6	4.05	14.42	55	$70\frac{7}{8}$
Georgia-Pacific	10	1,225.0	50.0	11	−35	4.1	7.0	0.47	2.81	25	$34\frac{7}{8}$
Firestone Tire	13	1,177.2	−13.8	−2	c	c	2.9	−0.24	0.94	$6\frac{5}{8}$	$13\frac{1}{2}$
Borden[d]	34	1,070.1	30.7	12	6	3.5	3.0	0.94	4.16	$22\frac{1}{8}$	$27\frac{5}{8}$
FMC	34	873.4	40.8	13	5	4.7	5.1	1.22	4.23	$22\frac{3}{4}$	$31\frac{1}{8}$
Kaiser Aluminum	14	750.1	73.5	6	31	9.8	8.0	1.67	5.67	19	$25\frac{5}{8}$
Pfizer	15	710.1	65.4	11	12	9.2	9.1	0.89	3.35	$38\frac{5}{8}$	$41\frac{3}{4}$
Eli Lilly	21	704.3	115.3	15	12	16.4	16.8	1.58	4.69	$50\frac{3}{8}$	$63\frac{7}{8}$
Borg-Warner	22	680.1	35.9	8	2	5.2	5.6	1.68	7.28	$33\frac{1}{4}$	$42\frac{7}{8}$
Northwest Industries	9	657.3	30.5	12	−11	4.[illegible]	5.8	0.98	5.48	$27\frac{3}{4}$	$37\frac{7}{8}$
Merck	16	655.0	106.0	16	17	16.2	16.1	1.41	5.27	$67\frac{7}{8}$	$75\frac{5}{8}$
Uniroyal	17	580.2	−12.1	−19	c	c	0.8	−0.45	−5.22	$3\frac{1}{8}$	7
Martin Marietta	12	567.1	34.5	30	5	6.1	7.5	1.39	7.20	$43\frac{1}{8}$	$57\frac{1}{4}$
General Tire[b]	10	513.3	−11.3	−1	c	c	2.7	−0.48	2.38	$15\frac{1}{2}$	$26\frac{7}{8}$
NL Industries	30	505.6	36.5	21	75	7.2	5.0	1.07	3.63	$40\frac{3}{8}$	$44\frac{1}{8}$
SCM	13	468.0	10.5	6	14	2.3	2.1	1.02	4.94	$24\frac{3}{4}$	32
Koppers	33	402.9	0.3	16	−92	0.1	1.2	0.00	3.12	$22\frac{5}{8}$	$31\frac{3}{4}$

[a] After-tax income as percentage of sales. [b] Excludes major nonrecurring earnings: Mobil—$459 million in 1980; Texaco—$402 million in 1980; Ashland Oil—$3.4 million loss in 1979; U.S. Steel—$14.8 million gain in 1980 and $90.4 million gain in 1979; General Tire—$1.5 million charge in 1979. [c] Deficit. [d] Earnings include nonrecurring items.

STOCK MARKET DATA

Stock price 12-Month low	Price-earnings ratio April 30	Annual indicated dividend April 30	Dividend yield, % of price
$49\frac{1}{8}$	5	$5.20	8.6%
$36\frac{1}{4}$	6	3.40	4.7
$36\frac{3}{4}$	5	2.40	6.8
$44\frac{3}{4}$	6	3.20	4.5
$25\frac{1}{8}$	5	2.25	5.6
60	9	3.60	3.5
$60\frac{7}{8}$	9	3.40	3.7
$37\frac{1}{4}$	8	2.80	4.1
31	5	2.20	4.7
34	6	1.80	4.2
18	3	1.50	6.3
$30\frac{5}{8}$	6	2.40	6.9
$49\frac{3}{4}$	5	3.60	5.2
$47\frac{5}{8}$	8	2.80	3.0
33	8	1.30	2.6
$59\frac{1}{8}$	6	4.80	5.1
$25\frac{3}{4}$	5	2.20	6.7
$15\frac{3}{4}$	6	1.48	8.4
46	10	1.80	2.6
$28\frac{3}{4}$	4	2.80	7.3
$20\frac{1}{8}$	4	0.96	3.3
44	7	2.80	5.9
$16\frac{1}{4}$	c	1.60	8.4
$62\frac{3}{4}$	9	3.40	4.8
$42\frac{7}{8}$	8	2.40	4.6
$10\frac{3}{4}$	6	1.30	10.8
$23\frac{3}{4}$	6	1.84	7.1
$46\frac{1}{4}$	9	2.80	5.3
$48\frac{3}{8}$	4	3.20	5.8
$21\frac{1}{2}$	9	1.20	4.8
$6\frac{1}{8}$	7	0.60	9.1
$19\frac{5}{8}$	5	1.90	8.6
$21\frac{5}{8}$	5	1.40	6.2
$15\frac{3}{8}$	3	1.20	6.3
29	11	1.44	3.7
$45\frac{3}{4}$	11	2.10	4.2
29	5	2.30	6.9
$24\frac{3}{4}$	5	2.05	7.4
$58\frac{1}{4}$	13	2.30	3.4
$3\frac{1}{8}$	c	0	0
$32\frac{1}{8}$	6	2.12	4.9
$12\frac{1}{4}$	7	1.50	9.7
21	11	1.20	3.0
$16\frac{5}{8}$	5	1.30	5.3
19	7	1.40	6.2

quarter. In the same period in 1979, these fibers contributed 32 cents a share to the company's earnings.

Monsanto's operating loss from textiles in the first quarter was $29.7 million, compared to a $5.4 million loss in operating income for the same quarter last year.

And at Du Pont, earnings from fibers in the first quarter declined 27% to 37 cents a share from the year-earlier quarter.

As in the past few quarters, the best performers are fertilizer-based companies. Texasgulf, which leads all 38 of the companies in profitability with a profit margin of 26.3%, had an earnings increase of 191% for the quarter. Company chairman Charles F. Fogarty says: "The outlook for Texasgulf is better than at any previous time in the company's history. Most facilities are operating at or near capacity, and demand for our products is good. We are selling all that we can produce."

Perhaps the most dramatic improvement has been at Beker Industries, which many industry analysts had all but written off as a near-bankrupt operation just a year and a half ago. Beker, with an infusion of capital from the sale of 50% of its phosphate ore reserves in Idaho last year, has moved steadily upward. The swing has been so dramatic that this quarter Beker had the fourth highest profit margin of all top 40 companies at 14.5%, compared to only 1.6% for the first quarter a year ago.

Other companies profiting from fertilizer include First Mississippi, Freeport Minerals, International Minerals, and, to some extent, W. R. Grace and PPG.

Agricultural chemical gains also were important in the first quarter for a number of nonbasic-chemical companies. However, like many other chemical operations within these diversified companies, the first quarter began to show some extremes of performance.

Borden chairman Eugene J. Sullivan put his finger on the best chemical operations for a number of companies in his observation that petrochemical and agricultural operations "contributed materially" to an improvement in operating income by the company's chemical division.

Even so, not all agricultural operations did this well, particularly in specialties. Whereas Eli Lilly reports another quarter of sales growth for its all-important Treflan herbicide, FMC reports that lower than anticipated sales of proprietary pesticides helped bring about an earnings decrease for the company's agricultural machinery and chemicals segment. And Kaiser Aluminum & Chemical, between these extremes, reports that earnings from its agricultural chemicals were about the same as a year ago.

If agricultural chemicals showed a somewhat mixed performance, petrochemicals were good to almost all producers. These were the preferred area to be in this winter: They proved a bonanza. For the petrochemical industry leader, Exxon, the first quarter brought an 80% year-to-year petrochemical earnings gain to $162 million on a revenue jump of 62% to $2.22 billion.

Other petrochemical earnings gains at major producers included 64% at Shell Oil, 74% at Texaco, 82% at Gulf Oil, and 343% at Standard Oil (Ind.).

At Standard Oil (Ind.), chairman of chemical operations John E. Swearingen says, "Generally firm market conditions enabled the company to maintain margins despite sharply higher raw material and operating costs." Gulf Oil comments that strong demand for benzene derivatives and the resulting significant price improvements for petrochemicals in 1979 carried over into the first quarter of 1980. Plastics operations also posted higher profits at Gulf.

Profitability improvement also was the story for oil companies' overall results. At 18 of the 20 largest chemical-producing oil companies in C&EN's earnings survey, overall profit margins on sales improved in first-quarter 1980 from first-quarter 1979.

Unfortunately, this was not generally the case for the other diversified chemical producers. Although in some cases chemicals outperformed other product lines, notably in the rubber industry, overall profit margins improved for only 10 of the 25 companies in this group in C&EN's survey. Some highly profitable companies found their margins nicked this time, including Eastman Kodak, 3M, and Eli Lilly.

As many of these checkered results show—such as deficits at Firestone, General Tire, and Uniroyal—1980 is beginning to look like a rough year for many companies. With the recession looming very large, it's safe to say that earnings will not hold the gains they have seen in the past year.

In fact, although earnings may increase somewhat in the second quarter, they may lose enough ground in the third and fourth quarters to flatten income for the year to the $5.7 billion figure for 1979. Sales for the year may well increase about 10% to more than $97 billion. As a result, profit margins would fall to an average 5.9% for the full year, from 6.4% in 1979. □

Canadian chemicals register good quarter

Four largest firms all posted sales, earnings increases in first quarter; but strong recovery that began in 1979 seems to be losing momentum

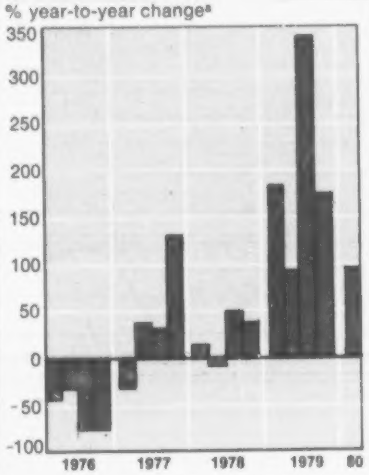
According to the figures, Canada's four largest publicly reporting chemical companies—C-I-L (formerly Canadian Industries Ltd.), Celanese Canada, Du Pont Canada, and Union Carbide Canada—all had at least a pretty good first quarter.

But the figures don't tell all. There are signs that the strong recovery that began early in 1979 is starting to lose momentum. There is also growing concern that increases, both actual and anticipated, in Canadian oil prices will end the Canadian producers' current advantage in world petrochemical markets.

Combined first-quarter sales for the four companies amounted to $765 million (Canadian), 22% higher than in the first quarter of 1979. Total earnings reached $50.5 million, a 94% increase from the year-earlier period. However, much of that increase stemmed from C-I-L and Carbide, which were comparing this year's first quarter with a downright dreadful first quarter in 1979. Overall, profit margins averaged 6.6%, up about 61% from last year's first quarter.

C-I-L posted first-quarter sales of $228 million, a modest 16% increase from the year-earlier period. However, earnings rebounded to $9.5 million, a 144% improvement over the first quarter of 1979. Then, C-I-L was suffering the effects of a lengthy strike at International Nickel, which is not only an important customer but also an important supplier of sulfur for C-I-L's sulfuric acid plants. C-I-L was in the costly predicament of having to buy sulfuric acid from others to meet its own delivery obligations.

First-quarter earnings show a 94% gain



[a] After-tax earnings of four largest publicly reporting Canadian chemical operations—Celanese Canada, C-I-L, Du Pont Canada, and Union Carbide Canada.

C-I-L president W. J. Mandry attributes much of the earnings improvement to "more realistic prices for agricultural chemicals, explosives, and plastics." He notes that strengthening of major C-I-L markets, including agriculture, mining, and pulp and paper, which began in 1979, persisted in the first quarter of 1980. Indications are, he adds, that this trend will continue.

At Celanese Canada, first-quarter sales amounted to $99.2 million, also a 16% increase from the 1979 period. Net income also was up but, at $5.2 million, it represented only a 6% improvement over the first quarter of 1979. Income from chemicals and industrial products rose significantly, according to Celanese president Richard M. Clarke. But overall results were affected by slackening in the textile-related economy. Although that weakness likely will continue for four to six months, "export opportunities" will help the firm maintain a balanced financial position, Clarke says.

Du Pont Canada had total first-quarter sales of $235 million, up 21% from the year-earlier period. Net income for the quarter came to $12.7 million, a 46% increase. The improvement reflects higher selling prices for most products and strong demand for nylon tire yarn, polyethylene pipe, finishes, and consumer products, says Du Pont president J. E. Newall.

However, Newall warns, "Slower business activity is evident in the automotive, furniture, carpet, apparel, and residential construction markets, and is being reflected in reduced demand for a number of our products." Consequently, he says, it's unlikely that Du Pont's 1980 earnings will match the record level reached in 1979.

Union Carbide Canada's sales came to $203 million in the first quarter, a 33% increase from the like period in 1979. But earnings soared 174%, to $23.1 million. Some of the earnings increase was due to changes in accounting policies; nevertheless, it was a good quarter.

"Plastics and chemicals continued to achieve exceptionally good results," says Carbide president J. S. Dewar, adding that gases, metals, and carbon products also had a strong quarter. However, Dewar doesn't expect first-quarter momentum to continue through the year. Product prices will stabilize, but costs will continue to rise, so that sales and earnings gains will moderate as the year goes on. Just the same, Dewar says, Carbide's 1980 results probably will exceed 1979's.

Ward Worthy, Chicago

Carbide is the most profitable of the four

	First-quarter 1980					
					Profit margin[a]	
$ Millions (Canadian)	Net sales	Change from 1979	Net income	Change from 1979	1980	1979
C-I-L	$227.7	16%	$9.5	144%	4.2%	2.0%
Celanese Canada	99.2	16	5.2	6	5.3	5.6
Du Pont Canada	234.8	21	12.7	46	5.4	4.6
Union Carbide Canada	202.8	33	23.1	174	11.4	5.5
TOTAL	$764.5	22%	$50.5	94%	6.6%	4.1%

[a] Net income as percentage of sales.

Chemical & Engineering NEWS

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WASHINGTON DC 20014

PHENOL, VINYL ACETATE

The recession begins to bite

A Key Chemicals Review Page 14

May 19, 1980
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Chemical & Engineering NEWS

Cover: USS Chemicals' phenol plant at Haverhill, Ohio. Photo courtesy of plant's builder, Pullman Kellogg

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- ***Bill establishing $600 million fund*** *to clean up hazardous waste dump sites reported out of House committee.* ***Page 7***
- ***Aerosols production increased*** *for the second year in a row in 1979; insect sprays showed the highest growth rate.* ***Page 7***
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Phenol and vinyl acetate hit by recession

Producers of key ingredients for adhesives and coatings are moving to withstand downturn in demand as slump deepens in housing and autos

A "foxhole mentality" characterizes U.S. producers of phenol and vinyl acetate at present. In effect, producers of these basic materials for adhesives and coatings are taking as conservative a stand as possible to ride out the deepening recession.

There is good reason for the current psychology. Demand in major markets for derivatives of phenol and vinyl acetate—housing, automobiles, and other consumer durable products—has fallen substantially, and the bottom is not yet in sight.

Therefore, the order of the day for phenol and vinyl acetate producers is stringent limits on inventories, production geared to current demand, and no plant capacity expansions. With such limitations, production of these two basic chemicals, used in making a host of other products, will fall at least 10% in 1980. More pessimistic sources foresee a 20% decline for phenol output and a somewhat smaller decline for vinyl acetate.

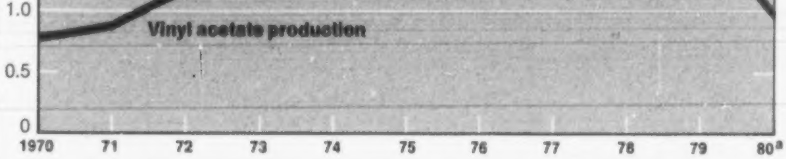
Longer term, production of these chemicals will recover as the major consumer markets recover. A suggestive pattern occurred in the previous major recession in 1974 and 1975. Phenol and vinyl acetate production followed the drastic decline in housing starts and recovered quite well as housing recovered in 1976.

If this pattern holds true in the current recession, phenol and vinyl acetate production will fall this year reflecting a slump in housing that began last year. Because of imprecision in yearly data, details are hard to pinpoint of the depth and duration of the slump in housing as well as in phenol and vinyl acetate production. However, in the past, it has been true that the more severe the recession, the sooner and more sharply it ended.

One significant characteristic of the previous recession expected again this time is a more drastic rate of decline in year-to-year housing starts than in related chemical production. Housing starts in 1980 may drop 40% from the 1979 annual rate to little more than 1 million units per year.

As a result, phenol production will be down a bit more than 15%, according to worst estimates. Vinyl acetate output will be down less, maybe 5 to 10%. By comparison, in 1974 and 1975, housing starts were off more than 35% year-to-year at the worst, whereas phenol and vinyl acetate production declined 25% and 15%, respectively.

Phenol, vinyl acetate output reflects housing starts cycles



a C&EN estimate. **Source:** Department of Commerce, International Trade Commission, industry and C&EN estimates

The recovery of the two chemicals may be slower than for housing after the current recession. Since phenol and vinyl acetate have many other uses, changes in their production are dampened compared to changes in housing. Unfortunately, some of these other uses may go down as much as housing but recover more slowly in terms of chemical demand.

Automobiles are an example. Phenol as resin derivatives goes into autos in many ways. But since use of these resins is unlikely to increase much per car on a year-to-year basis, recovery of phenol use in automobiles could be slow. U.S. automobile production may have to struggle to regain former levels, especially if auto imports hold even or gain a greater share of the market.

Similarly, demand recovery for these two chemicals will be slower than in the past. Both phenol and vinyl acetate are mature products with slowing growth rates in recent years. Few new, large-volume uses have come on the scene recently, and none has appeared that suggests large future demand.

At this time, too, little chance exists for cutting production costs of these chemicals very much and thereby stimulating new uses to accelerate demand growth. Although relatively cheap in most of their use areas, both chemicals are hydrocarbons that require net energy inputs for their manufacture. This means that production costs will follow crude oil prices closely. Vinyl acetate has a little more hope than phenol through a switch to a low-cost methanol-based production process.

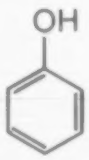
Small variations from the upward trend of hydrocarbon costs will occur, including some probably in 1980 in the current oil glut. These may relieve the strain on profitability somewhat for phenol and vinyl acetate as slackening demand shaves prices and profit margins on sales.

Producers hope to be able to resist price cutting to levels of unprofitability. If they do, their foxhole mentality will prove to have been well-advised caution.

Bruce Greek, Houston

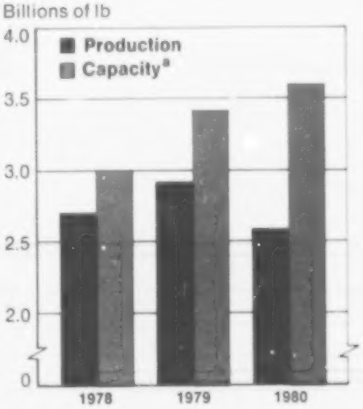
Key Chemicals

Phenol



- ***Production slowing***
- ***Capacity increasing***
- ***Price outlook weak***

PRODUCTION/CAPACITY



a As of first quarter.

HOW MADE

Peroxidation of cumene, then split into phenol and acetone

MAJOR DERIVATIVES

Phenol-formaldehyde resin 45%, bisphenol-A 20%, caprolactam 10%

MAJOR END USES

Adhesives 50%, fabricated plastics 20%, fibers 20%

FOREIGN TRADE

Exports—falling off in 1980 to below 250 million lb, imports—negligible

PRICES

Bulk-volume contracts, 36 to 38 cents a lb, with discounts

COMMERCIAL VALUE

$900 million for total production, 1979; $1 billion, 1980

U.S. producers of phenol have turned pessimistic on prospects for the rest of 1980, although they say they had a good first quarter.

The biggest reason for the switch is a sharp downturn in new housing construction, combined with a smaller slowdown in other kinds of construction. Phenol is tied to housing through phenol-based adhesives for making plywood. These and other adhesives take about half of all phenol consumed in the U.S.

Phenol still managed a good first quarter even with sliding housing starts because of the time it takes for slackened demand for plywood to work its way back through production of adhesives and then to raw material phenol. Since plywood demand is expected to remain low this summer, phenol demand will fall during the second half of 1980.

This decline, combined with slowing demand in other outlets, including exports, prompts forecasts for a 10% or greater decline in phenol output this year. A year ago prospects seemed good for 1980 phenol production to top 3 billion lb for the first time, but instead output will drop to about 2.6 billion lb, possibly lower, from 2.9 billion lb in 1979.

Recovery might start very late in 1980 but will have little effect on 1980 production. Housing may turn up during the fourth quarter of the year, but this would be too late to pull up phenol production. Other uses of phenol affected by the recession may be due for a spotty recovery if interest rates and inflation are still fairly high.

On the supply side, phenol has no real problems. Plant capacity increased in the first quarter from 3.4 billion lb to 3.6 billion lb. More new capacity is under construction or planned for possible production two or more years from now.

Hence, for two or three years, any phenol capacity lost to shutdowns for maintenance or startup difficulties in new units can easily be made up at other plants. Supplies of feedstock cumene and its raw materials, benzene and propylene, are good, although prices may increase during the year.

Prices for phenol have risen considerably during the past year as producers passed on costs of materials increased by crude oil price hikes. However, some temporary voluntary allowances (discounts) now exist from current posted phenol prices. This in theory could give producers of the chemical a chance to improve financial returns if demand increases.

But for the moment, sentiment concerns only more discounting or, alternatively, reducing production to levels of contract sales to minimize spot sales at unprofitable prices. If phenol demand slows further as expected in the second half of 1980, price increases should be minimal or nonexistent unless crude oil prices shoot up.

Lower effective prices can't do much to spur phenol consumption. No significant competitor at any price exists for phenol-formaldehyde resins, for bisphenol-A in epoxy or polycarbonate resins, or for phenol derivatives in a host of small-volume uses. Also, phenol is a very small part of the total cost in many of the durable products in which it reaches the final consumer.

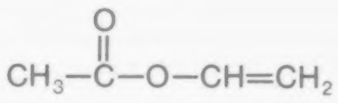
Besides housing, another vital durables market for phenol is autos. Since U.S. auto sales are down a third or more from a year ago, phenol use in brake linings, sand molds for castings, engineering plastics parts, and electrical parts has suffered.

Phenol exports also are expected to feel the impact of recession as it moves through the world. U.S. exports will decline at least 10% and possibly 20% from the 1979 level of about 270 million lb.

About the brightest part of the outlook for phenol is low inventories downstream. Inventories of plywood are well down from traditional levels as manufacturers severely limit production to keep in line with construction demand. These low inventories mean that demand for phenol could rise rapidly once housing demand starts to rise. Similar low inventories and rapid recovery prospects exist for other end uses of phenol.

For the moment, however, 1980 will not be a banner year for phenol. Producers can't be optimistic, since they recall that in the previous 1974–75 recession phenol production slumped about 25% in much the same durables climate as today.

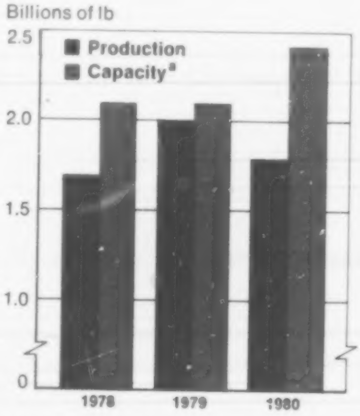
Vinyl Acetate



$CH_3{-}\overset{\overset{\displaystyle O}{\|}}{C}{-}O{-}CH{=}CH_2$

- ***Demand slowing***
- ***Capacity adequate***
- ***Prices stable***

PRODUCTION/CAPACITY



[a] As of first quarter.

HOW MADE

Reaction of acetic acid, ethylene, and oxygen

MAJOR DERIVATIVES

Polymers 55%, polyvinyl alcohol 20%

MAJOR END USES

Adhesives 30%, paint 30%

FOREIGN TRADE

Exports—down from 600 million lb in 1979 to less than 400 million lb in 1980, imports—negligible

PRICES

Contracts 34 cents a lb with discounts

COMMERCIAL VALUE

$550 million for total production, 1979; $650 million, 1980

In 1980, U.S. vinyl acetate producers will have much the same type of problems afflicting phenol. Both U.S. demand and exports will decline, bringing total production down 5 to 10% from 1979 to 1.8 billion lb.

Plant capacity will hold at about 2.4 billion lb, with no expansions other than minor debottlenecking expected this year. Certainly in 1980 and 1981 no further capacity will be necessary and producers may have to tolerate an excess.

Prices, now posted at about 34 cents a lb, are up about 20% from a year ago. However, significant further increases will come only if ethylene prices are pushed up by a major crude oil price rise. Ethylene prices are declining at present.

Vinyl acetate output is due for a pause this year after several years of substantial growth. The reason is the same as for phenol—the housing market. A majority of vinyl acetate production eventually ends up in houses, largely as adhesives and coatings, but also as a host of other products. The impact of a radical slowdown in new housing starts certainly will affect vinyl acetate demand, although not so greatly as it will affect phenol.

Paint, a big consumer of polyvinyl acetate emulsions, is relatively less affected by a slowdown in housing than are adhesives for plywood, the major use of phenol. Paint has a shorter lifetime than plywood for both aesthetic and performance reasons. Hence, at times like the present, when new houses are expensive and when more home owners are unemployed, repainting flourishes.

The result is that trade sales of paints, usually through retail outlets, rise during a recession. If this occurs as expected during the current recession, vinyl acetate demand will hold up better than would be expected strictly from the decline in new housing starts.

Adhesive uses, the other major housing application of polyvinyl acetate, range from holding panel walls together in mobile homes to giving textured surfaces to wallboard.

Frequently, adhesives of polyvinyl acetate contain varying quantities of polyvinyl alcohol, another vinyl acetate derivative. The alcohol acts as a thickener and as an additive with polyvinyl acetate and cellulosic materials in making rewettable adhesives for labels and tapes.

Since paints and adhesives account for more than 60% of U.S. consumption of vinyl acetate, it is easy to see why, in a recession, demand will be under downward pressure. But other derivatives often are affected even more by an economic downturn.

For example, about 10% of vinyl acetate production goes into various kinds of textile and other sizings (surface-treating agents), either as polyvinyl acetate or alcohol. Since textiles already are suffering from the recession, these uses also will slump. Another smaller sizing use currently hurting is in glass fibers used in reinforced-plastic products such as boats.

Exports account for a relatively large share of vinyl acetate production, reaching nearly 25% of the total during 1979. This is a very high percentage for a U.S. organic chemical. The cost advantage of U.S. ethylene producers led to such large derivatives exports even with growing capacity in other parts of the world.

As the U.S. cost advantage diminishes and more capacity for vinyl acetate and derivatives comes on stream outside the U.S., exports from this country are expected to decline. A recession worldwide would hasten the export decline in 1980 to less than 20% of U.S. production.

Reduced production of vinyl acetate certainly will hurt the production cost picture and profitability in 1980. However, most producers buy the ethylene needed on the merchant market, where prices are currently falling. Also, producers are going to cheaper processes for making acetic acid from methanol. As a result, their cost controls might be better than in other chemicals, and producers may be able to slow the expected decline in profitability.

Overall though, vinyl acetate producers, like those of most other U.S. chemicals, will have to wait out the recession and work at keeping plant operating efficiency as high as possible, given lower operating rates. No new uses of any size will appear to offset declines in existing major uses, many of which already dominate the markets they are in.

Chemical &
Engineering
NEWS
May 26, 1980

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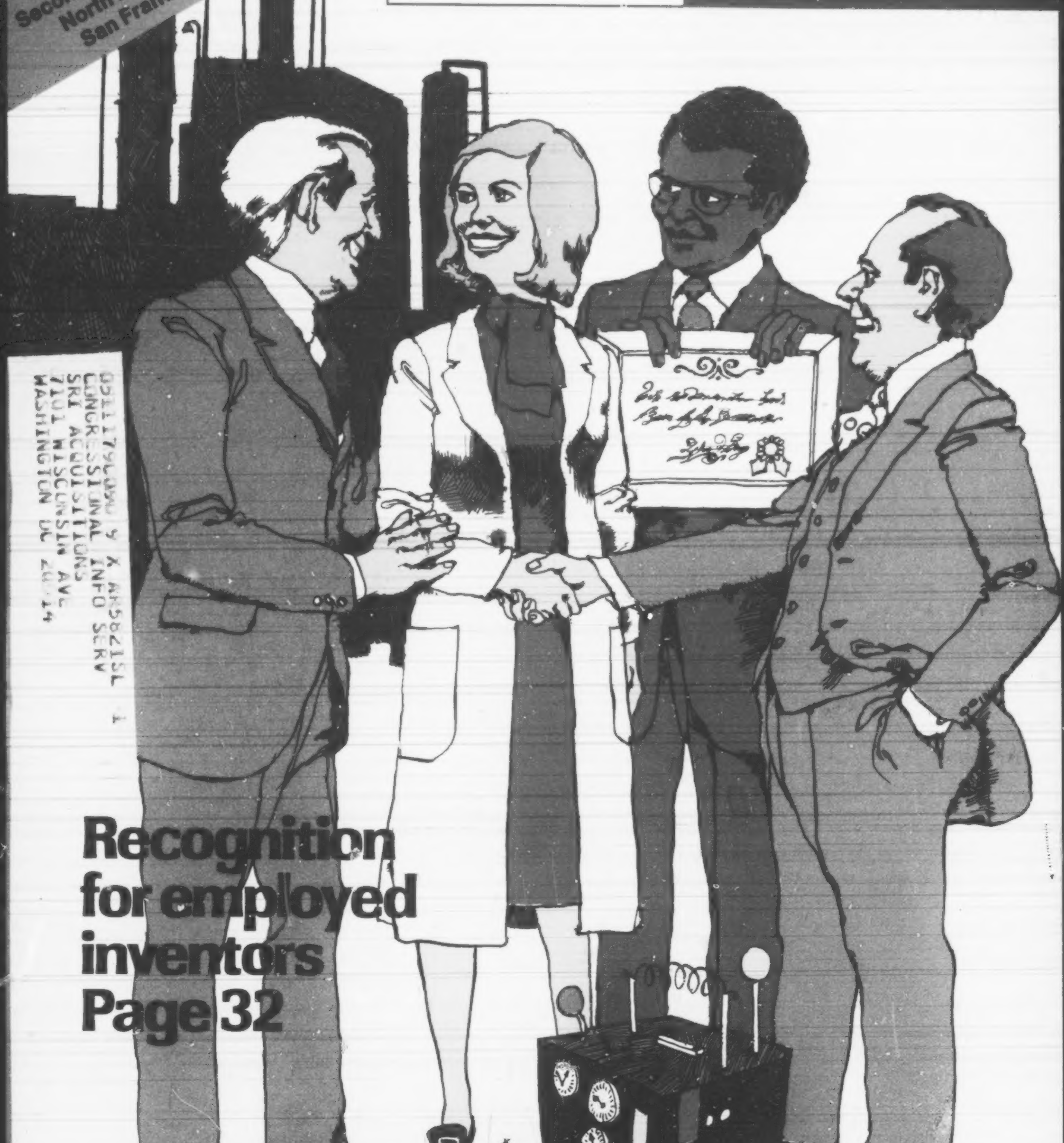
Second Chemical Congress of the
North American Continent
San Francisco Page 43



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Recognition for employed inventors Page 32

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- ***Corco's acceptance of a takeover offer*** *by Charter Co. may spell the end of its financial problems.* ***Page 7***
- ***Monsanto shuts down*** *a third of its polyester filament capacity, citing low demand, decreased profitability.* ***Page 7***
- ***Major U.S. companies plan to hire*** *10% more college graduates this year than in 1979 despite the business recession.* ***Page 7***
- ***Workers will have access*** *to exposure and medical records under new standard issued by the Occupational Safety & Health Administration.* ***Page 8***
- ***OECD delegates agree*** *to international acceptance of toxicity testing data done under organization's guidelines.* ***Page 8***

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- ***Foreign sales,*** *as exports and as goods produced in overseas plants, climbed 29% in 1979 to nearly a third of all sales of 20 companies surveyed by C&EN.* ***Page 14***

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- ***Proposed bill*** *to establish mechanism within OSTP for assessing comparative risk involved in federal regulatory actions in scientific fields debated at hearings.* ***Page 22***

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- ***Different forms of arsenic*** *can be distinguished with analytical method developed by USDA scientists.* ***Page 31***

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Preliminary Program

- ***Symposia, special events*** *listed for the Second Chemical Congress of the North American Continent, sponsored by ACS and Canadian and Mexican societies.* ***Page 43***

Chemical firms boast strong overseas sales

Foreign sales of 20 U.S. chemical companies surveyed by C&EN rose 29% in 1979, account for nearly a third of their overall sales

William J. Storck
C&EN, New York

For the past year or more U.S. chemical companies have been boasting of the extraordinary successes they have been achieving overseas. Both exports from the U.S. and products produced in their foreign plants have been selling well, they say. With final figures for 1979 now available, it appears the companies have good reason for boasting.

Overseas sales for 20 U.S. chemical companies surveyed by C&EN increased 29% to $20.3 billion in 1979. This is a faster rise than that for total sales for these companies and thus it shows that their foreign business in 1979 grew faster than domestic business. Total sales, both domestic and overseas, grew 22% to $64.4 billion for these companies from 1978. Domestic sales increased only 20% in 1979 from 1978—a respectable figure, but in last year's boom, indicative of some signs of underlying weakness in the domestic economy.

U.S. producers have long used their overseas business to buffer lagging U.S. sales. The recession year of 1975 gives a good example of how the chemical industry can do this. Since the recession did not hit all parts of the world at the same time, U.S. producers, faced with a weak domestic economy, were able to sell their products in stronger foreign economies. During 1975, the 20 U.S. producers surveyed increased their foreign sales 24% while their total revenues stagnated at an 0.1% increase. Meanwhile, their sales in the U.S. in 1975 declined 9.7% from the year before.

The increase in sales abroad last year pulled the foreign sales percentage of total sales for the 20 companies up to 32% in 1979 from 30% the year before. The 1979 figure is the highest since 1975, when foreign sales made up 34% of total revenues for the 20 companies. Foreign sales gains for the 20 have been outperforming total sales gains for the past two years. Besides the 29% increase in 1979, foreign sales grew 19% in 1978 compared to a 12% gain for total sales. This has resulted in an increase in foreign sales as a percentage of the total—moving from 28% in 1977 to 30% in 1978 to 32% last year.

However, it has not been all roses for foreign sales. After their big surge in 1975, foreign sales grew only 6.5% in 1976 and in 1977 they grew at a very lackluster 1.4%.

By far the biggest gainer for 1979, as it had been the year before, of companies surveyed was Allied Chemical, with an increase, spurred by North Sea oil, of 67% in foreign sales. The year before foreign sales at Allied had grown 69%. These two increases are well above Allied's average annual increase since 1973 of just 28% for foreign sales. The increases have pushed foreign sales as a percentage of total sales to 26% at Allied in 1979 from just 15% in 1973.

Dow Chemical, however, was by far the leader in dollar volume of foreign sales. In 1979, Dow racked up $4.67 billion in sales overseas, an increase of 44% from 1978. At the same time Dow pushed its foreign sales as a percentage of the total to 51%, thus buffering the cyclical nature of many of its U.S. businesses. Dow's $4.67 billion in overseas sales was 39% higher than that of the the second-place firm, Du Pont, the number one U.S. chemical company in terms of total sales. Du Pont had $3.36 billion in foreign sales last year, an increase of 31% over the year before and 27% of total sales.

Ferro, which has extensive holdings in South America, was the leader in 1979 in terms of foreign sales as a percentage of total sales at 57%, down slightly from 58% the year before. However, all is not bright in Ferro's overseas business. The company's 1979 annual report says, "Rampant inflation and severe currency devaluations resulted in only a modest contribution from our second largest

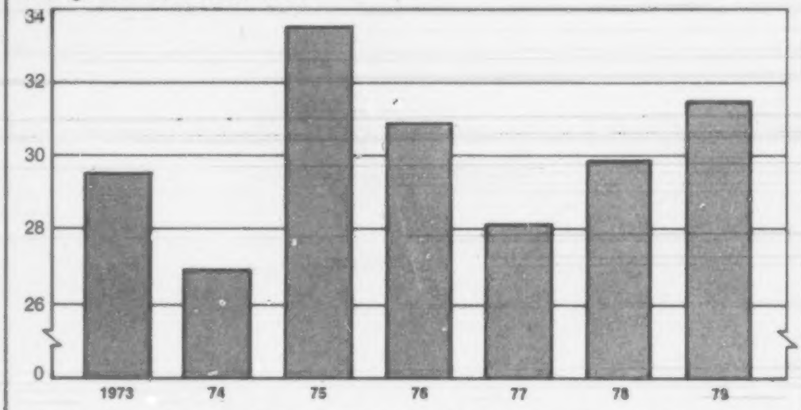
Foreign sales growth bests average in past two years

$ Millions	Foreign sales[a]			% change		Annual change
	1979	1978	1977	1978–79	1977–78	1973–79
Allied Chemical	$1,103.0	$ 662.0	$ 392.0	66.6%	68.9%	27.7%
American Cyanamid	1,125.3	955.0	799.0	17.8	19.5	15.4
Cabot	286.5	189.7	166.5	51.0	13.9	17.3
Crompton & Knowles	50.6	46.5	28.6	8.8	62.6	12.8
Dow Chemical	4,672.0	3,242.0	2,777.0	44.1	16.7	22.2
Du Pont	3,356.3	2,571.9	2,173.4	30.5	18.3	21.4
Ethyl Corp.	411.8	297.1	247.6	38.6	20.0	25.6
Ferro	338.8	286.6	228.2	18.2	25.6	17.3
B. F. Goodrich	604.9	508.9	446.6	18.9	13.9	4.7
W. R. Grace	1,577.0	1,420.0	1,257.0	11.1	13.0	7.3
Hercules	588.0	433.0	345.3	35.8	25.4	6.3
International Flavors	179.6	244.6	208.9	−26.6	17.1	8.5
Liquid Air	154.6	138.8	127.2	11.4	9.1	11.9
Loctite	68.0	47.9	38.5	42.0	24.4	27.8
Mallinckrodt	55.3	41.0	34.7	34.9	18.2	23.8
Monsanto	1,954.3	1,387.6	1,185.0	40.8	17.1	17.0
Rohm & Haas	561.0	437.0	369.0	28.4	[illegible].4	12.4
Stauffer Chemical	270.8	213.8	177.5	26.7	20.5	26.5
Union Carbide	2,782.0	2,534.0	2,247.0	9.8	12.8	13.0
Witco	160.2	134.5	116.3	19.0	15.6	14.1
TOTAL	**$20,299.6**	**$15,790.1**	**$13,265.3**	**28.6%**	**19.0%**	**16.0%**

[a] Foreign sales are exports plus sales of overseas output.

Foreign share of sales peaked in 1975, is moving up again

Foreign sales as % of total sales[a]



a Foreign sales are exports plus sales of overseas output. **Note:** For 20 U.S. chemical firms listed in tables.

subsidiary, Ferro Brazil . . . . Although Latin American markets continued to grow in 1979, net income of the company's Brazilian subsidiary declined approximately \$3.3 million, primarily because of substantial cost inflation coupled with government price controls which prevented implementation of timely sales price increases. Brazilian profits also were adversely affected by higher interest expense for borrowed money and the high level of borrowings made to finance 1979 expansions."

The problem of Brazil seems to be continuing for Ferro. In Ferro's first-quarter report, Ferro president and chief executive officer Adolph Posnick again complained about Brazilian price controls. "While price increases are being granted, obtaining such approvals during the first quarter of this year has not kept pace with Brazilian inflation," he stated.

American Cyanamid, as well as other companies operating in Brazil, was hard hit by the devaluation of the Brazilian cruzeiro in 1979.

Other firms with above average foreign sales as a percentage of total sales include American Cyanamid at 35%, International Flavors & Fragrances 44%, Liquid Air and Loctite 42%, and Rohm & Haas 35%.

Most companies increased foreign sales share in 1979

	Foreign sales as % of total sales[a]						
	1979	1978	1977	1976	1975	1974	1973
Allied Chemical	25.5%	20.3%	13.4%	16.1%	17.9%	17.2%	15.3%
American Cyanamid	35.3	34.8	33.1	35.0	40.0	36.0	32.3
Cabot	25.4	26.5	28.6	30.1	33.1	38.7	36.1[b]
Crompton & Knowles	21.1	21.4	14.8	16.2	27.0	27.0	20.0
Dow Chemical	50.5	47.1	44.5	45.6	43.9	47.0	45.8
Du Pont	26.7	24.3	23.0	27.1	27.0	27.6	19.2
Ethyl Corp.	24.5	20.7	19.0	19.9	21.0	14.7	15.0
Ferro	57.2	58.0	54.3	52.0	54.5	52.0	48.9
B. F. Goodrich	20.2	19.6	20.1	26.1	29.4	28.7	27.7
W. R. Grace	29.9	31.9	30.2	34.3	36.6	37.8	36.6
Hercules	25.1	22.2	20.3	19.6	36.7	39.9	35.4
International Flavors	43.9	66.8	66.5	64.0	65.9	62.5	63.4
Liquid Air	41.9	45.6	44.7	47.1	49.3	46.2	44.8
Loctite	42.1	37.5	36.6	36.2	38.5	43.0	41.9
Mallinckrodt	14.1	11.2	11.1	10.8	11.6	10.8	9.6
Monsanto	31.6	27.6	25.8	30.3	29.4	28.6	28.8
Rohm & Haas	35.3	34.9	32.8	37.3	40.7	38.3	35.2
Stauffer Chemical	17.7	16.1	14.4	15.9	13.5	12.3	10.6
Union Carbide	30.3	32.2	31.9	33.0	34.2	34.3	34.0
Witco	16.6	17.9	18.4	18.0	19.2	20.3	19.6
TOTAL	**31.5%**	**29.9%**	**28.1%**	**30.9%**	**33.5%**	**26.9%**	**29.5%**

a Foreign sales are exports plus sales of overseas output. b C&EN estimate.

In addition to Allied, firms with better than normal growth in overseas sales were Cabot Corp. 51%, Dow Chemical 44%, Du Pont 31%, Ethyl 39%, Hercules 36%, Loctite 42%, Mallinckrodt 35%, and Monsanto 41%.

The only one of the companies surveyed by C&EN whose foreign sales decreased in 1979 was International Flavors and Fragrances. IFF's overseas sales fell 27% to \$179.6 million last year. Because of this drop, foreign sales as a percentage of total sales at IFF fell to 44% in 1979 from a noteworthy 67% the year before.

During 1979, unlike the last boom year of 1974, there seems to have been enough excess U.S. capacity that product could be readily produced for export. And, indeed, exports probably made up a large part of the increase in foreign business for U.S. chemical companies. A good example is Union Carbide, which had only a 9.8% gain in total foreign business last year. However, according to the company's annual report, exports were 15% of foreign sales.

What 1980 holds is hard to say so far. In the first quarter foreign sales were still gaining.

At Du Pont's annual meeting, president Edward G. Jefferson reported that international business continued to record strong sales in first-quarter 1980, with gains registered in all geographic areas. Total sales outside the U.S. were \$1.2 billion, 28% above last year. "Exports of products manufactured in the U.S. continued strong and accounted for about 45% of our overseas business," Jefferson stated.

At Hercules, president Alexander F. Giacco said, "Internationally, 40% of total company sales [in the first quarter] were from outside the U.S., with more than 50% of profits derived from overseas businesses." This is an improvement over full-year 1979, when overseas sales at Hercules were 25% of total company sales.

Carbide notes that once again foreign sales gains are ahead of domestic gains. At Carbide in the first quarter international sales increased 20% and exports increased 23% compared to the first quarter of 1979. At the same time domestic sales increased 17%.

Monsanto notes that continued strong demand for exports "from our plants in the U.S." is offsetting the softness in those product lines closely related to the auto and housing industries.

If the first-quarter trend holds up, once again U.S. producers may get what they want—buffering of a U.S. recession by stronger economies abroad. However, if the foreign economies begin a downturn soon, all bets are off. □

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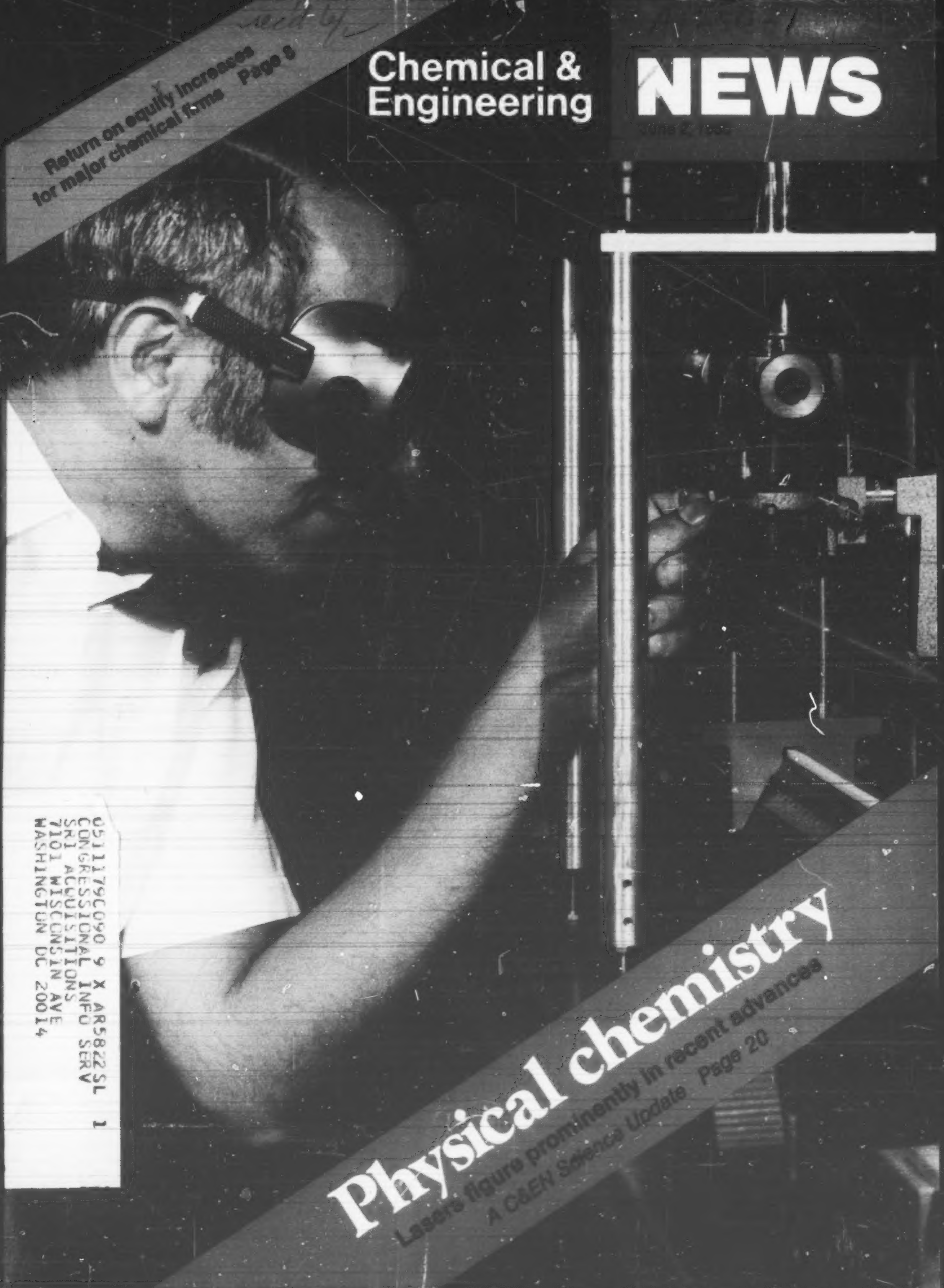
Chemical & Engineering NEWS

June 2, 1980

Return on equity increases for major chemical firms Page 8



Physical chemistry

Lasers figure prominently in recent advances

A C&EN Science Update Page 20

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Cover: Naval Research Lab chemist uses argon ion laser to measure low-temperature Raman spectrum of alkali halide crystals

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- ***Royal Society of Chemistry,*** *formed by merger of two U.K. chemical societies, is headed by Sir Ewart Jones.* ***Page 4***
- ***The petrochemical industry may suffer*** *feedstock shortages under present allocation rules, GAO reports.* ***Page 5***
- ***A picture of the surface of Venus*** *is emerging from radar mapping data provided by NASA's Pioneer orbiter.* ***Page 5***
- ***NRC's Food & Nutrition Board report*** *emphasizes nutritious, well-balanced diet, moderate use of salt.* ***Page 6***
- ***Esso Nederland*** *will build a pilot plant to convert coal to methane.* ***Page 6***
- ***EPA okays*** *resuming use of nitrilotriacetic acid in detergents.* ***Page 6***

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- ***Chemical firms' return on equity rises*** *after declining since 1974.* ***Page 8***

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- ***Chromatopyrography*** *improves pyrolysis CG by separating analysis of polymer and its volatile components.* ***Page 26***
- ***Fermentation unit sets record*** *of 75 days of nonstop production.* ***Page 27***

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Return on equity turns up for chemical firms

Average return on equity for 36 basic chemical firms rose to 15.7% last year, after steadily declining from high of 17.9% in 1974

William J. Storck
C&EN, New York

Return on equity, or profits as a percentage of stockholders' equity, turned up steeply for 36 basic chemical companies last year, according to C&EN calculations. Average return on equity increased to 15.7% in 1979 for these companies from just 13.1% the year before.

The gains were good for both large and small chemical firms. For 21 companies with sales of more than $1 billion, average return on equity jumped to 15.4% from 12% in 1978. For the other 15 companies, return on equity rose to 17.7% from 14.8% the year before.

Return on equity is calculated by dividing after-tax income by total stockholders' equity. Stockholders' equity is normally made up of the par value of the stock issued by a company, the capital surplus of that stock over par value, and retained earnings. Although most corporations figure return on equity using average stockholders' equity during the year, C&EN has computed it by using stockholders' equity at year's end, thus yielding more conservative figures.

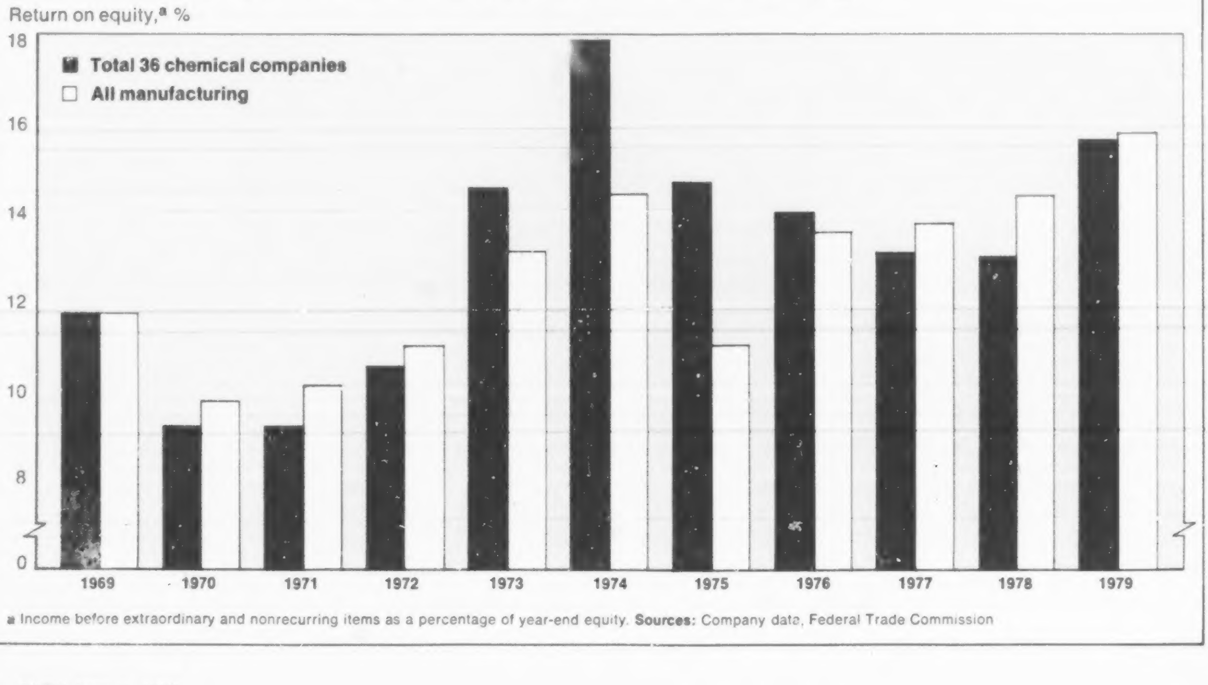
The increase in return on equity for the chemical companies ends an erosion that began after it hit a decade high of 17.9% in 1974. Since then return on equity has declined steadily to 13.1% in 1978.

The upturn came more quickly for smaller chemical companies than for larger ones. In 1974 return on equity averaged 20% for 15 chemical companies with 1979 sales of less than $1 billion. By 1977, it had slipped to 12.1% after a bounce from 11.9% in 1975 to 12.9% in 1976. In 1978, however, return for these firms rose to 14.8%, then increased again in 1979 to 17.7%.

The 21 larger firms, which last year accounted for about 89% of equity and 87% of profits, had to wait until 1979 to see an increase in return on equity. After hitting 17.5% in 1975, return on equity took a dive to 12.0% in 1978. Only in 1979 were these larger companies able to increase return on equity, when it rose to 15.4%.

In 1979, earnings for the 21 larger companies increased an average of 29.2% from 1978 to a total of $4.6 billion, and equity increased 10.2%. Earnings for the 15 smaller companies increased an average of 65.4% to a total of $681 million, and stockholders' equity was increasing a much more modest 23.5% from the year before. For the 36 companies as a whole, profits increased 32.9% from 1978 to a combined $5.2 billion, and equity increased 11.3% to $33.7 billion.

One of the biggest factors causing the spurt in return on equity for the 15 smaller companies was a big runup in long-term debt during 1979. When debt increases, stockholders' equity is moderated, thus increasing return on equity. During 1979, long-term debt among the 15 smaller firms in-



Return on equity spurts for chemicals, but trails all manufacturing

a Income before extraordinary and nonrecurring items as a percentage of year-end equity. **Sources:** Company data, Federal Trade Commission

Return on equity for smaller firms outpaces that for big chemical companies

Return on equity[a]	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969
CHEMICAL COMPANIES WITH MORE THAN $1 BILLION IN SALES[b]											
Air Products	17.2	15.7	15.9	17.2	19.9	17.4	7.4	9.6	7.8	9.6	9.1
Akzona	7.9	6.8	2.5	1.8	2.5	10.4	11.8	8.2	9.4	11.5	14.5
Allied Chemical	14.3	9.4	11.6	11.4	11.2	14.9	10.6	7.8	6.4	5.5	9.1
American Cyanamid	12.5	12.4	11.9	12.4	14.3	15.2	12.7	12.2	11.2	11.9	13.0
Cabot	18.4	14.5	14.0	11.1	6.5	10.9	9.1	8.1	8.4	10.0	8.7
Celanese	13.5	11.8	9.4	9.3	7.2	10.6	10.7	8.0	9.1	8.0	12.6
Diamond Shamrock	17.5	14.9	20.4	20.8	21.4	19.5	11.6	7.0	6.7	8.1	8.0
Dow Chemical	20.1	16.9	17.9	21.5	25.9	28.9	17.6	14.1	12.8	11.5	12.8
Du Pont	19.5	17.4	13.4	12.1	7.6	11.5	17.5	13.7	12.6	12.3	14.1
Ethyl Corp.	16.0	14.1	14.8	14.5	14.0	18.6	15.4	13.9	13.2	13.0	13.0
W. R. Grace	14.2	12.2	11.7	11.8	15.9	14.5	11.0	8.6	6.3	7.5	7.0
Hercules	15.3	12.6	7.6	14.4	4.9	14.0	15.4	12.9	10.8	11.7	11.1
International Minerals	15.3	16.7	16.7	23.3	35.4	18.6	10.2	8.8	6.0	2.2	1.6
Monsanto	11.9	11.7	11.5	16.2	15.5	18.4	16.0	9.4	7.7	6.5	9.0
National Distillers	15.1	12.3	12.0	13.8	11.2	16.4	9.6	7.5	7.0	7.7	8.7
Olin	9.6	9.1	12.0	12.2	11.1	9.9	8.5	7.0	4.8	4.3	7.6
Pennwalt	13.7	13.4	13.5	12.3	12.0	11.1	9.1	7.5	6.1	5.8	7.9
Rohm & Haas	15.1	10.4	7.9	8.9	5.8	14.4	12.8	12.4	9.9	9.1	11.2
Stauffer Chemical	16.0	16.6	17.1	18.9	19.3	19.4	13.5	10.5	8.2	8.8	10.3
Union Carbide	13.8	10.8	11.3	14.4	13.9	21.0	14.1	10.8	8.3	8.7	10.5
Williams Cos.	9.3	4.1	8.5	8.2	17.9	18.2	12.6	12.9	13.7	16.9	17.0
CHEMICAL COMPANIES WITH LESS THAN $1 BILLION IN SALES[b]											
Big Three Industries	15.6	15.9	15.7	13.4	14.9	16.4	12.9	11.3	14.0	14.7	24.0
Crompton & Knowles	10.8	10.2	9.7	8.6	5.0	9.2	9.9	9.0	5.3	8.7	10.0
Ferro	15.2	15.5	13.2	14.0	10.5	16.0	17.9	14.6	12.3	9.6	12.7
First Mississippi	4.9	4.5	4.6	18.0	17.6	127.0	169.3	36.0	11.2	c	c
Freeport Minerals	26.7	10.4	6.2	14.0	10.7	25.0	11.8	7.3	5.7	6.9	12.4
International Flavors	21.5	22.2	20.8	19.6	14.4	20.2	22.5	20.0	18.3	18.6	18.8
Lubrizol	24.2	24.0	21.4	19.5	20.3	24.9	21.6	18.4	18.7	20.1	19.2
Mallinckrodt	18.0	14.6	15.4	15.4	14.0	14.6	12.1	10.1	9.6	9.0	7.8
Nalco Chemical	24.2	19.7	24.1	23.8	20.3	19.6	20.4	18.9	18.2	16.1	20.2
Petrolite	16.7	18.3	21.8	22.0	18.5	18.9	15.1	12.4	11.7	13.6	11.4
Reichhold Chemicals	7.5	6.2	7.2	10.8	12.3	20.9	11.6	9.1	4.4	4.1	9.5
Stepan Chemical	11.3	10.6	14.0	14.4	12.7	15.3	13.9	11.6	10.3	10.0	11.1
Texasgulf	15.7	6.5	6.2	8.1	16.2	27.8	19.2	4.8	5.1	10.2	18.0
Virginia Chemicals	13.4	14.2	11.5	17.2	11.9	12.2	11.6	8.2	7.2	4.4	13.2
Witco Chemical	18.1	16.5	-3.7	14.2	9.4	17.0	13.4	11.3	9.6	10.3	11.0
21 LARGEST COMPANIES	**15.4**	**13.2**	**13.3**	**14.2**	**15.2**	**17.5**	**14.6**	**10.7**	**9.3**	**9.1**	**11.6**
15 OTHER COMPANIES	**17.7**	**12.4**	**12.1**	**12.9**	**11.9**	**20.0**	**14.5**	**9.7**	**8.5**	**9.8**	**13.1**
TOTAL 36 COMPANIES	**15.7**	**13.1**	**13.2**	**14.0**	**14.7**	**17.9**	**14.6**	**10.6**	**9.2**	**9.2**	**11.8**

a After-tax income before extraordinaries and nonrecurring items as a percentage of stockholders' equity. b Based on 1979 sales. c Deficit.

creased 38.1% to $1.08 billion at the end of 1979 from $782 million at the end of 1978. The increase for the larger firms was much more modest. Year-end debt for 1979 for the 21 bigger firms stood at $14 billion, a 9.8% increase from year-end 1978.

However, in spite of the hefty increase in return on equity, it is not all good news for chemical companies. Even with large increases in profits last year, chemical companies still lag the average for all manufacturing in return on equity, although they closed the gap considerably in 1978. Although return on equity for chemical companies increased to 15.7% in 1979 from 13.1% the year before, return on equity for all manufacturing as figured by the Federal Trade Commission increased to 15.8% last year from 14.4% in 1978. In fact, the last year that the chemical industry led the all-manufacturing category in return on equity was in postrecession 1976. But most important, chemicals led all manufacturing by a wide margin (17.9% to 14.4%) in the boom year of 1974. This may parallel 1979 as a year immediately preceding recession, but it does not parallel in terms of the comparison of return on equity.

Last year was not good for all of the chemical companies in terms of return on equity, either. Of the 36 companies, return on equity declined for seven. These companies were International Minerals & Chemical and Stauffer Chemical, among the larger firms, and Big Three Industries, Ferro, International Flavors & Fragrances, Petrolite, and Virginia Chemicals among the smaller ones.

The leader in return on equity among the smaller companies and for the whole group was Freeport Minerals with 26.7%. Freeport was followed among the smaller firms by Lubrizol and Nalco Chemical, both with 24.2%. Among the larger companies, Dow Chemical was second, with 20.6%. The lowest return on equity, 4.9%, was chalked up by First Mississippi. □

Women on chemistry faculties: jobs still few

The toehold that women have on the faculties of Ph.D.-granting chemistry departments continues to be just that—a toehold. But at least it has doubled in recent years.

The latest survey conducted for the American Chemical Society's Women Chemists Committee reveals that during the 1978–79 academic year 129 women were on such faculties. This represented 3.0% of the total. The first survey conducted for the committee covered the 1970–71 academic year. It showed just 60 women on Ph.D.-granting chemistry faculties—1.5% of the total.

A closer look at the numbers reveals a drop over these years in the number of faculties with no women and a corresponding gain in those with just one. And a C&EN analysis of the data seems to indicate that women are still being hired in disproportionately low numbers—apparently at a lower rate than might be expected from their substantial and growing representation in new Ph.D. graduating classes.

The information for these surveys, which were also conducted for the 1972–73, 1974–75, and 1976–77 academic years, has been obtained from the Directory of Graduate Faculties, which is published by ACS. The studies include women only with the rank of assistant professor or above.

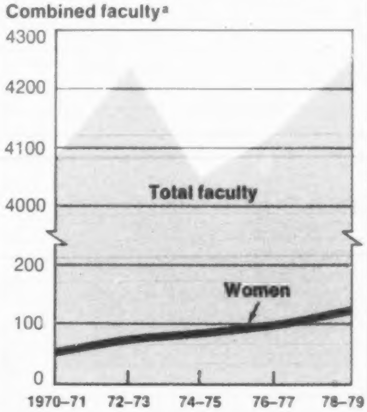
If a 4% attrition rate among faculty members is assumed, it appears that hiring by Ph.D.-granting chemistry departments must have totaled approximately 1500 during the eight-year period covered by the studies. If the same attrition rate is assumed among women faculty members, it appears that about 100 of this 1500, or about 7%, were women. By contrast, 11% of Ph.D. graduating classes over these years were women.

The initial study, for the 1970–71 academic year, revealed that of a total of 188 Ph.D.-granting chemistry departments the faculties of 139, or 74%, had no women. By 1978–79 this was down to 96, or 51% of the total. Over the same period the number of faculties with one woman member increased from 32 to 67.

Ten faculties have moved from no women in 1970–71 to two women in 1978–79. These are Brown University; University of California, San Diego; University of Colorado; Massachusetts Institute of Technology; University of Massachusetts, Amherst and Boston; New Mexico State University; New York University, Washington Square; University of North Carolina; Purdue University; and University of Texas, Austin. Over these same years, the chemistry faculty at the University of Maryland moved from one woman to three. The biggest gain of all for women was posted at the combined faculty of the colleges associated with the University of Massachusetts, the gain being from one woman out of a total of 13 faculty members in 1970–71 to five women out of a total of 24 in 1978–79.

Thirteen chemistry faculties had fewer women in 1978–79 than in 1970–71. They include Rockefeller University, down from three to one; the University of Cincinnati, down from two to zero; and the University of Houston, down from two to one. And the following 10 schools dropped from one to zero: George Washington University; Georgetown University; Louisiana State University; University of Nebraska, Lincoln; University of New Hampshire; University of New Orleans; University of Pittsburgh; Temple University; Texas Technical University; and Virginia Commonwealth University. ☐

Women make up 3% of Ph.D.- granting faculties



a Of all Ph.D.-granting chemistry departments.
Source: Report compiled for ACS Women Chemists Committee

These are the largest all-male faculties

School	Total faculty[a]
U of California, Los Angeles	42
U of Minnesota	39
U of Illinois, Urbana	37
Louisiana State U, Baton Rouge	35
U of Florida	33
State U of New York, Stony Brook	33
U of Nebraska, Lincoln	32
U of Washington	32
U of Chicago	31
Iowa State U	31
U of Pittsburgh	31
Brigham Young U	30
U of California, Davis	30
Georgia Institute of Technology	30
Oregon State U	30
U of Arizona	29
Cornell U	29
Colorado State U	28

a For 1978–79 academic year.

These chemistry faculties have at least two women

School	Faculty[a]	
	Total	Women
U of Massachusetts, associated colleges	24	5
Portland State U	21	5
Rutgers U, New Brunswick	40	5
American U	13	4
Polytechnic Inst. of N.Y.	19	4
U of Maryland	49	3
Auburn U	28	2
Brown U	22	2
U of California, San Diego	34	2
City U of New York	87	2
U of Colorado	33	2
U of Delaware	27	2
Massachusetts Inst. of Technology	40	2
U of Massachusetts, Amherst and Boston	38	2
U of Missouri	17	2
New Mexico State U	22	2
NYU, Washington Square	22	2
U of North Carolina	33	2
Northern Illinois U	22	2
Purdue U	49	2
U of Southern Mississippi	14	2
U of Texas, Austin	42	2
U of Toledo	20	2
Utah State U	14	2
U of Wyoming	17	2

a For 1978–79 academic year.

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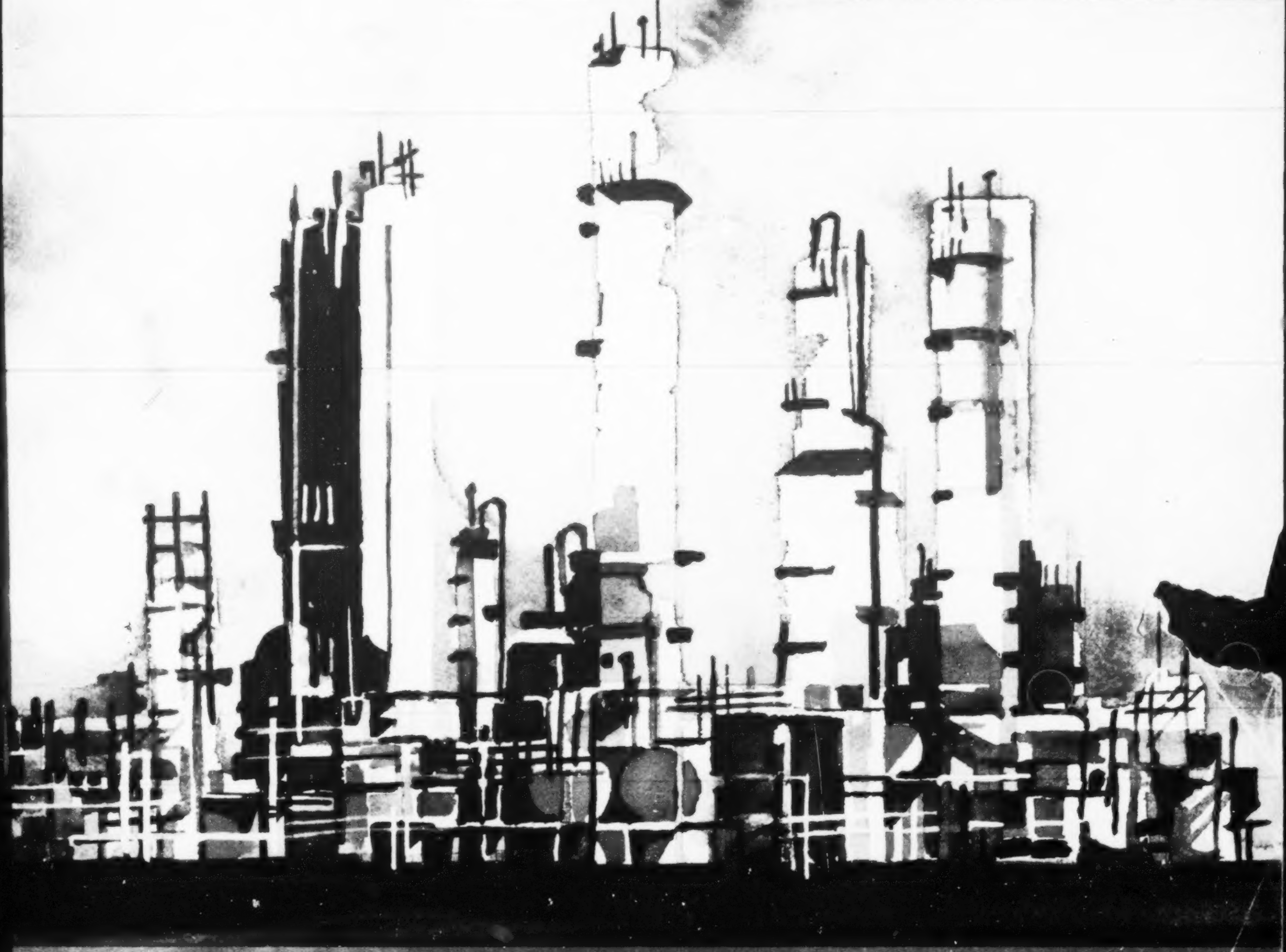
Chemical & Engineering NEWS

June 9, 1980



Facts & Figures

for the chemical industry Page 33

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News of the Week

- ***The recession has hit the chemical industry*** *and the short-term outlook for recovery isn't bright, Chemical Manufacturers Association spokesmen say.* ***Page 6***
- ***Union Carbide will sell*** *ferroalloys operations and related metals operations at 10 locations to a group of Norwegian and Canadian investors.* ***Page 6***
- ***New electrolytic process for copper refining*** *could reduce energy use 25%, eliminate sulfur dioxide emissions.* ***Page 7***
- ***The Gossamer Penguin,*** *a 50-lb aircraft outfitted with photovoltaic cells to power its electric motor, may be the forerunner of more rugged solar-powered planes.* ***Page 7***
- ***Analytical system*** *that automatically channels optimum quantity of sample components into a gas chromatograph/mass spectrometer developed by GE scientists.* ***Page 8***
- ***Science can play a big part*** *in solving the nation's energy, food, and health problems, says National Science Foundation five-year outlook study.* ***Page 8***

Business

- ***New Helium-Energy Act*** *would open up new markets for the now-wasted gas, set specific targets for storage; considered an improvement over previous bills.* ***Page 11***
- ***Air Products' new science center*** *initially will explore fundamental research in five targeted areas.* ***Page 12***

Government

- ***Third calendar*** *of upcoming government rules and regulations, published by the Regulatory Council, updates agencies' proposals for the year.* ***Page 14***

Science

- ***The eruption at Mount St. Helens*** *provides opportunity to determine health and environmental dangers of ash as well as its effect on soil chemistry.* ***Page 19***
- ***Wisconsin researchers*** *discover polysilastyrene, new family of silicon polymers with unique properties; investigate ways to use them.* ***Page 20***
- ***Dietary recommendation*** *from the National Research Council's Food & Nutrition Board draws sharp controversy over cholesterol stance.* ***Page 22***

Facts & Figures

C&EN's yearly survey of the chemical industry *shows U.S. production up in 1979, especially for petrochemicals; higher profit margins; favorable trade balance; foreign firms fare well also.* ***Page 33***

ACS News

- ***ACS calls for revision*** *of the food safety laws in a public policy statement to Congressional subcommittees.* ***Page 92***

Special Report

Facts & Figures for the chemical industry

U.S. chemical producers in 1979 enjoyed the fourth straight year in which business trends generally were favorable. Output ran well ahead of the year before, although by year's end there were some signs that the pace was slackening. Selling prices climbed as producers strived to recover surging costs for raw materials and energy. Sales volume was spurred, as a result, and profits were never higher. The chief concern, as the year drew to a close, was that with recession spreading throughout the U.S. economy, the chemical industry's favorable results of the past two or three years would not be matched again in 1980. These results are spelled out in the tables and graphs on the following pages of Facts & Figures, C&EN's annual report on the chemical industry that it has published since 1956.

C&EN has gathered the information presented in Facts & Figures from many sources, including government agencies, trade associations, and the companies that manufacture chemicals and their many related products. To provide further insight, these data in many cases have been used to develop information on growth rates, measures of performance, and other indicators that help to evaluate how well the industry has met the challenges of the past decade.

Facts & Figures is divided into six sections. The first four detail various aspects of operations in the U.S. chemical industry. The fifth covers world trade in chemicals. The final section presents data on chemical industries in Canada, Japan, and Western Europe. Added to these for the first time this year are figures from Eastern Europe and China, two areas for which such information has been sparse in the past.

Section one: Production
Production of chemicals in the U.S. Growth trends for minerals, organic and inorganic industrial chemicals, plastics, man-made fibers, synthetic rubber, and fertilizers. 35

Section two: Finance
Sales and earnings of U.S. chemical companies. Profitability. Stock prices. Financial analysis. Cash flow. Capital spending. R&D outlays. Individual company data. 43

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Productivity and labor costs. Plant capacity and capacity utilization for major chemicals. Energy use in the chemical and petroleum industries. 65

Section four: Employment
Employment trends by company and by industry. Employment of scientists. Wage rates. Workweek. 68

Section five: Foreign trade
World trade in chemicals. U.S. trade balance and share of world chemical markets. U.S. foreign trade in chemical products by product classes and geographical areas. 70

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Production of chemical products in Western Europe, Japan, Canada, Eastern Europe, and China. Industry trends. Foreign trade. Company results. 72

Facts & Figures at a glance

Production of chemical products, overall, was 7% higher in the U.S. last year than it had been the year before. Plastics, as usual, recorded the greatest growth, up 13%. But output actually declined for paints.

Strength in plastics and fibers set the stage for big gains in output of several major petrochemical intermediates. Among inorganic compounds, chlorine and sodium hydroxide had banner years in production. So did phosphoric and nitric acids. All three major plant nutrients tallied better-than-average gains in production. Much of the growth can be credited to notable increases in exports of ammonia and phosphates. But U.S. consumption also rebounded from depressed 1978 levels.

High-density polyethylene and polypropylene set the pace among the plastics materials. Production also was up strongly for polyolefin and polyester fibers. A no-growth year for SBR took the luster off synthetic rubber output as a whole, however.

Producers of industrial chemicals increased their sales 22% last year, with higher selling prices a big factor. Profits expanded about 28%, moreover. As a result, both profit margins and return on stockholders' equity improved a bit.

Chemical companies' spending this year for new plant and equipment is expected to be well above 1979 outlays. But the increase largely will be offset by inflated construction costs. Spending for R&D also is due for a respectable boost.

Productivity continues to rise in the chemical industry, although the rate of improvement is slower than in many years of the past decade. The industry operated its plants closer to capacity last year than in those immediately preceding, but operating rates are slipping in 1980. The chemical industry used less energy in 1978 than it had in 1972, before the oil embargo, thanks largely to a drop in consumption of natural gas.

The number of people working in the chemical industry increased about 1.5% for the fourth year in a row, with the number of scientists and engineers up about twice that rate.

Exports of chemicals from the U.S. leaped a remarkable 37% last year, largely reflecting sharply higher foreign sales of both organic chemicals and plastics materials. Imports also were higher, but the U.S. trade surplus in chemicals was better than ever, approaching $10 billion. Trade in chemicals worldwide swelled 30% to $122.5 billion.

Business generally was favorable in foreign chemical industries. Production and sales were higher in Western Europe; so were earnings. In Japan, output climbed 9%, led by plastics; profitability also improved. Sales vaulted 19% in Canada, largely because of price increases; Canada's trade balance swung from deficit to a small surplus. Output continued to rise in Eastern Europe, but at a rate generally slower than in previous years. China reported some large increases in chemical production, particularly for fertilizer materials.

SECTION 1 PRODUCTION BY THE U.S. CHEMICAL INDUSTRY

Output of chemicals rose 7% last year

U.S. chemical plants increased their output steadily throughout last year. For 1979 as a whole, production of chemicals and allied products was about 7% higher than in the previous year. That's an annual rate of growth considerably higher than what was chalked up by all U.S. industry during the year and one that was slightly better than the average rate for the chemical industry alone during the past decade. As 1980 began, however, it was becoming clear that the pace of expansion was slowing and, indeed, that year-to-year comparisons soon will be turning unfavorable.

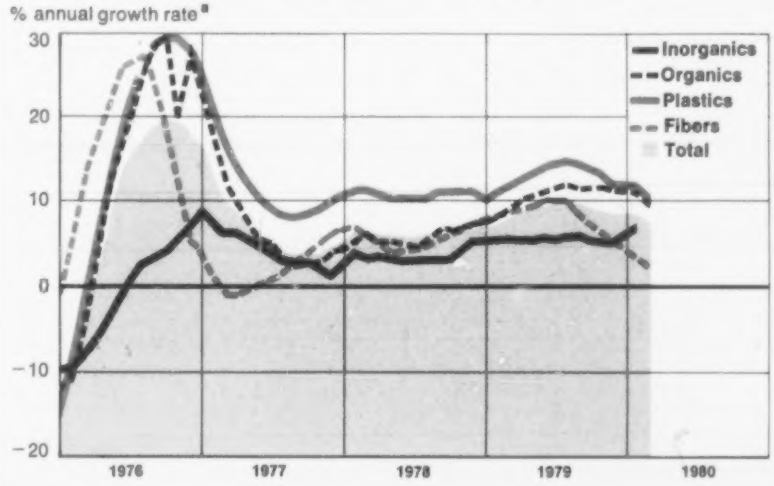
As usual, plastics and resins scored the best gains in production, with a rise of more than 10%. Among the top-volume plastics, the polyolefins did particularly well.

Man-made fibers had an above-average year as well, aided by heavy export demand and paced by polyester and polyolefin fibers. But a lackluster year—the second in a row—for big-volume styrene-butadiene rubber stymied growth for synthetic rubbers overall. Hurting from a switch toward longer-lasting and smaller tires, output of SBR has been trending downward since 1973.

Growth in plastics and fibers spilled over into petrochemical intermediates, such as ethylene and ethylene glycol, aromatic hydrocarbons, terephthalic acid, and acrylonitrile. In general, however, output of organic chemicals expanded a bit slower last year than in 1978.

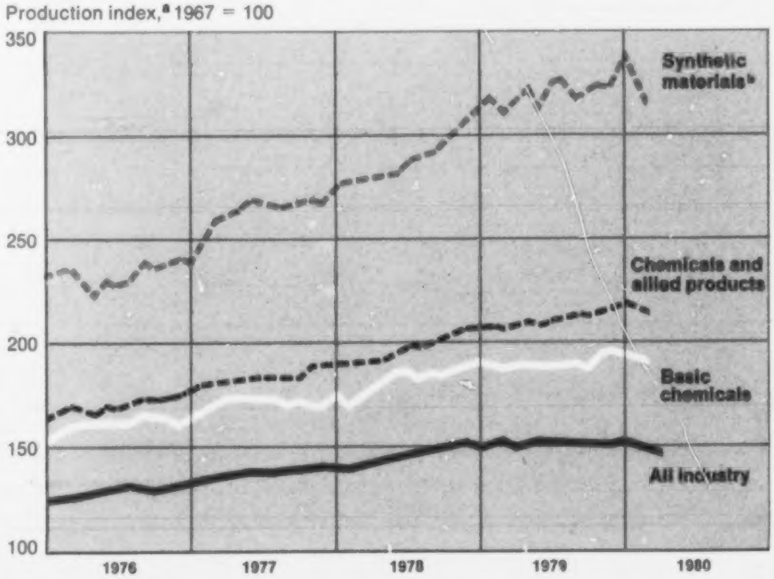
Among inorganic chemicals, production of chlorine and sodium hydroxide showed surprising strength, especially in comparison with the year before. Some of the materials tied to fertilizers—such as phosphoric and nitric acids, ammonium nitrate, and ammonia—also turned in good performances. And fertilizers themselves were buoyed both by export markets that were strong for the second straight year and by increased use of plant nutrients by U.S. farmers.

Growth rates for chemical production are slowing



a Average running annual growth rates in production of major plastics, inorganic and organic chemicals, and all chemicals, and in shipments of man-made fibers. **Sources:** International Trade Commission, Bureau of the Census, Society of the Plastics Industry, Textile Economics Bureau

Synthetics have spurred recent growth in chemical output



a Seasonally adjusted. b Includes plastics, synthetic rubber, and man-made fibers.
Source: Federal Reserve Board

TOP 50 CHEMICALS: Growth last year focused on organic chemicals

Rank			Production				Average annual change			
			Billions of lb		Common units[b]					
1979	1978[a]		1979	1978	1979	1978	1978–79	1977–78	1974–79	1969–79
1	1	**Sulfuric acid**	83.98	82.18	41,988 tt	41,088 tt	2.2%	7.1%	4.9%	3.5%
2	2	**Lime**[c]	38.78	38.78	19,392 tt	19,389 tt	0	2.4	−1.0	−0.1
3	4	**Ammonia**	36.24	34.38	18,121 tt	17,188 tt	5.4	−2.2	2.9	3.6
4	3	**Oxygen**	35.35	35.43	427 bcf	428 bcf	−0.2	8.9	1.8	4.5
5	5	**Nitrogen**	29.92	28.41	413 bcf	392 bcf	5.4	18.4	13.0	12.0
6	6	**Ethylene**	29.19	25.96	29,187 mp	25,955 mp	12.5	2.1	4.1	5.9
7	8	**Sodium hydroxide**	24.78	21.42	12,392 tt	10,710 tt	15.7	−2.0	2.1	2.3
8	7	**Chlorine**	24.22	22.10	12,108 tt	11,052 tt	9.6	4.5	2.4	2.6
9	9	**Phosphoric acid**	20.27	18.72	10,135 tt	9,358 tt	8.3	4.5	7.1	6.4
10	11	**Nitric acid**	17.13	15.87	8,564 tt	7,934 tt	7.9	−0.2	1.1	1.7
11	10	**Sodium carbonate**[d]	16.51	16.58	8,253 tt	8,290 tt	−0.4	0	1.8	1.6
12	12	**Ammonium nitrate**[e]	15.60	14.41	7,800 tt	7,207 tt	8.2	0.4	0.7	2.9
13	13	**Propylene**	14.30	13.01	14,298 mp	13,013 mp	9.9	1.0	6.4	7.1
14	15	**Urea**[f]	13.53	10.89	13,534 mp	10,888 mp	24.2	22.5	12.3	8.6
15	16	**Benzene**	12.72	10.94	1,730 mg	1,488 mg	16.3	−3.1	3.0	3.9
16	18	**Toluene**[g]	11.86	7.64	1,636 mg	1,054 mg	55.2	−1.2	12.1	8.0
17	14	**Ethylene dichloride**	11.82	11.00	11,821 mp	11,001 mp	7.5	0	5.2	7.0
18	17	**Ethylbenzene**	8.53	8.39	8,530 mp	8,385 mp	1.7	0.9	7.1	5.7
19	20	**Vinyl chloride**	7.54	6.94	7,544 mp	6,941 mp	8.6	16.0	6.1	7.2
20	19	**Styrene**	7.48	7.19	7,484 mp	7,186 mp	4.0	4.6	4.7	4.9
21	22	**Methanol**	7.41	6.44	7,411 mp	6,443 mp	15.1	−0.2	1.5	5.8
22	25	**Terephthalic acid**[h]	7.26	5.95	7,263 mp	5,954 mp	22.0	10.1	11.3	13.9
23	21	**Carbon dioxide**[i]	7.07	6.69	3,533 tt	3,180 tt	5.7	12.9	13.0	11.7
24	24	**Xylene**[g]	6.89	6.13	950 mg	845 mg	12.4	0.7	3.4	9.5
25	23	**Formaldehyde**[j]	6.45	6.38	6,446 mp	6,380 mp	1.1	5.5	2.3	3.9
26	26	**Hydrochloric acid**	5.95	5.58	2,973 tt	2,790 tt	6.6	2.5	3.8	4.5
27	27	**Ethylene oxide**	5.28	5.01	5,277 mp	5,012 mp	5.4	14.8	4.7	4.5
28	28	**Ethylene glycol**	4.60	3.90	4,597 mp	3,903 mp	17.9	6.2	6.6	6.0
29	30	***p*-Xylene**	4.18	3.52	4,175 mp	3,516 mp	18.8	10.8	9.1	9.9
30	32	**Cumene**	4.00	3.38	3,995 mp	3,380 mp	18.3	27.8	6.6	9.0
31	29	**Ammonium sulfate**	3.94	3.87	1,971 tt	1,943 tt	1.8	−11.0	−1.4	0.3
32	31	**Butadiene (1,3-)**[k]	3.55	3.52	3,551 mp	3,515 mp	0.9	10.8	−0.7	1.3
33	34	**Acetic acid**	3.33	2.78	3,329 mp	2,775 mp	19.8	8.0	5.2	6.5
34	33	**Carbon black**	3.33	3.35	3,329 mp	3,346 mp	−0.6	−0.5	−0.1	2.3
35	35	**Phenol**[l]	2.95	2.68	2,945 mp	2,682 mp	10.1	14.7	5.1	6.1
36	38	**Acetone**	2.50	2.52	2,502 mp	2,519 mp	−0.8	13.5	4.8	5.1
37	36	**Aluminum sulfate**	2.46	2.62	1,232 tt	1,309 tt	−5.9	4.3	−0.3	−0.2
38	39	**Cyclohexane**	2.41	2.33	2,412 mp	2,331 mp	3.4	4.0	0.5	0.8
39	37	**Sodium sulfate**[m]	2.34	2.34	1,173 tt	1,168 tt	0.4	−2.5	−2.7	−2.3
40	41	**Propylene oxide**	2.25	2.05	2,249 mp	2,047 mp	9.8	9.7	5.1	6.7
41	40	**Calcium chloride**[n]	2.03	2.06	1,015 tt	1,031 tt	−1.5	6.6	−4.0	−1.4
42	42	**Acrylonitrile**	2.02	1.75	2,018 mp	1,752 mp	15.4	6.4	7.4	5.7
43	44	**Vinyl acetate**	1.98	1.69	1,983 mp	1,692 mp	18.6	6.7	7.2	10.5
44	43	**Isopropyl alcohol**	1.97	1.73	1,968 mp	1,730 mp	13.9	−8.4	0.3	−0.5
45	45	**Adipic acid**	1.80	1.62	1,800 mp	1,621 mp	11.1	5.6	4.0	4.0
46	46	**Sodium silicate**	1.55	1.60	777 tt	802 tt	−3.1	5.5	0.1	1.7
47	48	**Sodium tripolyphosphate**	1.51	1.48	756 tt	739 tt	2.3	3.1	−3.5	−4.6
48	47	**Acetic anhydride**	1.51	1.50	1,505 mp	1,500 mp	0.7	0	−1.6	−1.0
49	49	**Titanium dioxide**	1.48	1.40	741 tt	701 tt	5.7	2.0	−1.2	2.2
50	50	**Ethanol**[l]	1.31	1.27	1,308 mp	1,267 mp	3.1	−5.4	4.2	−5.7
	TOTAL INORGANICS IN TOP 50		**374.44**	**359.28**			**4.3%**	**4.5%**	**3.1%**	**3.2%**
	TOTAL ORGANICS IN TOP 50		**190.62**	**166.10**			**14.8%**	**3.4%**	**5.5%**	**6.1%**
	GRAND TOTAL OF TOP 50		**565.06**	**525.38**			**7.6%**	**4.2%**	**3.8%**	**4.1%**

a Revised. **b** tt = thousands of tons, bcf = billions of cubic feet, mp = millions of pounds, mg = millions of gallons. **c** Except refractory grade. **d** Synthetic and natural. **e** Original solution. **f** Primary solution. **g** All grades. **h** Includes both acid and ester, without double counting. **i** All forms. **j** 37% by weight. **k** Rubber grade. **l** Synthetic only. **m** High and low purity. **n** Solid and liquid. **Sources:** Bureau of the Census, Bureau of Mines, International Trade Commission, C&EN estimates

PRODUCTION: Gains in 1979 were above the long-term trend by a small margin

Industrial production indexes, 1967 = 100	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	Annual change 1978–79	Annual change 1969–79
Total index	152.2	146.1	138.2	130.5	117.8	129.3	129.8	119.7	109.6	107.8	111.1	4%	3%
Manufacturing, total	153.2	146.8	138.4	130.3	116.3	129.4	129.8	118.9	108.2	106.4	111.0	4	3
Nondurable manufacturing	163.3	156.9	150.5	141.8	126.4	134.6	133.8	126.5	116.6	112.3	111.5	4	4
Chemicals and products	210.4	197.4	185.7	170.9	147.2	159.4	154.5	143.6	125.9	120.4	118.4	7	6
Chemicals and synthetic materials	232.8	216.7	201.1	185.1	154.1	176.7	171.9	156.4	135.8	120.9	125.0	7	6
Basic chemicals	190.9	181.9	171.8	161.8	135.9	153.3	147.7	137.7	123.7	117.9	117.0	5	5
Alkalies and chlorine	131.4	119.7	119.2	119.0	106.5	125.6	123.8	120.2	114.4	119.1	115.1	10	1
Gases, coal tar, inorganic pigments	193.7	186.0	174.3	164.4	133.3	165.0	157.8	146.5	125.6	123.0	127.8	4	4
Basic organic chemicals	233.3	221.2	204.7	189.8	155.3	177.9	170.0	155.3	139.7	128.7	125.3	5	6
Inorganic chemicals, nec	133.8	129.3	128.5	124.3	112.9	112.6	110.8	107.8	99.2	97.7	97.6	3	3
Acids and fertilizer materials	140.5	133.6	124.2	117.6	108.4	116.6	113.1	111.5	105.3	106.2	104.9	5	3
Synthetic materials	318.2	287.6	260.8	232.5	191.0	224.4	221.1	194.7	160.4	145.1	141.2	11	8
Plastics materials	415.7	366.5	320.3	280.1	213.1	258.5	243.3	217.4	166.2	155.7	148.6	13	11
Synthetic rubber	130.5	127.5	124.5	118.7	101.2	129.7	135.6	126.9	117.2	114.8	117.7	2	1
Man-made fibers	270.7	250.9	236.8	214.3	191.2	214.4	220.1	189.1	164.9	142.2	139.8	8	7
Chemical products	189.0	179.0	170.9	157.2	140.7	142.8	137.7	131.3	116.4	114.2	112.0	6	5
Drugs and medicines	238.2	220.6	213.9	191.5	174.1	179.6	170.1	155.5	135.1	127.5	119.0	8	7
Soap and toiletries	171.6	163.8	155.0	143.0	127.7	128.1	129.0	130.3	114.1	116.9	111.1	5	4
Paints	126.2	132.6	125.8	122.8	114.2	119.2	114.7	118.0	111.1	105.6	112.0	−5	1
Agricultural chemicals	221.6	211.8	201.1	185.4	163.9	144.6	127.0	108.9	103.5	107.9	106.1	5	8
Petroleum products	143.6	145.2	142.6	133.5	124.1	124.7	128.5	122.1	116.7	113.2	108.4	−1	3
Rubber and plastics products	270.0	253.6	232.3	199.7	166.7	195.2	184.1	172.4	147.6	132.3	130.2	6	8

nec = not elsewhere classified. **Source:** Board of Governors of the Federal Reserve System

MINERALS: Sulfur makes best showing among large-volume materials

Thousands of tons	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	Annual change 1978–79	Annual change 1969–79
Bromine, production	250^{a}	223	217	230	204	216	209	193	178	175	168	12%	4%
Iodine, consumption^{b}	4.3^{a}	4.0	4.3	3.6	3.1	3.8	3.5	3.4	3.3	3.2	3.0	8	4
Imports^{c}	3.1	3.4	3.5	3.2	2.7	4.0	3.1	3.1	3.6	3.0	2.9	−9	1
Lime, production^{d}	20,435^{e}	20,484	19,987	20,257	19,159	21,645	21,132	20,332	19,635	19,788	20,250	0	0
Phosphate rock, marketable production	56,891	55,156	52,091	49,231	48,806	45,676	42,128	40,823	38,878	38,731	37,718	3	4
Exports	15,827	14,187	14,584	10,398	12,270	13,895	13,873	14,272	12,584	11,735	11,334	12	3
Potash (K_2O equivalent),^{f} production	2,453	2,484	2,457	2,400	2,501	2,552	2,603	2,659	2,587	2,729	2,804	−1	−1
Imports^{g}	5,691	5,186	5,076	4,594	3,797	4,326	3,587	2,961	2,766	2,605	2,332	10	9
Apparent consumption^{h}	7,624	6,838	6,605	6,150	5,113	6,086	5,563	4,816	4,815	4,728	4,720	11	5
Salt, total sold or used^{i}	43,100^{e}	42,896	43,439	44,218	41,057	46,565	43,939	45,051	44,106	45,928	44,277	0	0
Evaporated	6,000^{j}	5,872	5,704	5,634	5,372	5,951	5,913	5,879	5,956	5,530	5,695	2	1
Rock	14,200^{j}	14,688	14,958	15,668	14,283	14,835	12,347	14,434	13,700	14,170	13,397	−3	1
Salt in brine^{k}	22,800^{j}	22,336	22,777	22,917	21,401	25,779	25,680	24,737	24,449	26,228	25,185	2	−1
Sodium carbonate, production^{l}	8,253	8,290	8,040	7,560	7,130	7,566	7,535	7,523	7,163	7,071	7,035	0	2
Sulfur, production^{m}	13,339	12,318	11,824	11,992	12,610	12,789	12,231	11,444	10,730	10,703	10,690	8	2
Apparent consumption^{n}	15,145	13,889	12,850	12,060	11,875	12,115	11,463	11,036	10,274	10,334	10,269	9	4
Frasch, production	7,007	6,226	6,520	7,016	8,077	8,849	8,518	8,165	7,868	7,932	8,004	13	−1
Apparent consumption^{n}	7,466	6,506	6,309	6,041	6,439	7,001	6,680	6,753	6,328	6,283	6,422	15	2
Recovered elemental, production^{o}	4,486^{p}	4,478^{p}	3,995	3,514	3,326	2,948	2,706	2,184	1,787	1,631	1,593	0	11
Apparent consumption^{n}	5,833	5,769	5,232	4,558	4,228	4,123	3,775	3,132	2,725	2,766	2,619	1	8
Other, production^{q}	1,845	1,615	1,310	1,462	1,208	992	1,008	1,096	975	1,140	1,093	14	5
Apparent consumption^{n}	1,845	1,615	1,310	1,462	1,208	992	1,008	1,152	1,220	1,285	1,228	14	4

a Estimated. **b** Estimated apparent consumption of crude elemental iodine. **c** Crude elemental iodine. **d** Includes Puerto Rican production. **e** Preliminary. **f** Includes muriate and sulfate of potash, potassium magnesium sulfate, and parent salts; excludes other chemical compounds containing potassium. **g** Includes nitrate of potash. **h** Calculated from sales plus imports minus exports. **i** Total obtained by all recovery methods that was sold or used by domestic producers (figures differ slightly from U.S. production figures); figures include Puerto Rican production. **j** C&EN estimate. **k** Sold or used as such. **l** Natural and synthetic. **m** Sulfur content basis. **n** Calculated from shipments plus imports minus exports (sulfur content basis). **o** From natural gas plants and petroleum refineries, plus a small quantity from a coking operation. **p** Includes a small quantity from utility plants. **q** From by-product sulfuric acid (basis 100%) produced at copper, zinc, and lead plants, and from pyrites, hydrogen sulfide, and liquid sulfur dioxide. **Source:** Bureau of Mines

ORGANIC CHEMICALS: **Majority of leading products were made in greater quantities in 1979**

Millions of lb unless otherwise noted	Production											Annual change	
	1979[a]	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1978–79	1969–79
Acetic acid, synthetic	3,329	2,776	2,570	2,463	2,197	2,584	2,429	2,235	1,956	1,932	1,770	20%	7%
Acetone	2,502	2,519	2,219	1,869	1,640	1,980	1,989	1,818	1,538	1,615	1,518	−1	5
Acrylonitrile	2,019	1,752	1,646	1,518	1,215	1,412	1,354	1,115	979	1,039	1,157	15	6
Aniline	681	606	584	544	407	551	458	410	366	398	334	12	7
Benzene, mg[b,c]	1,730	1,488	1,457	1,425	1,024	1,488	1,453	1,252	1,076	1,134	1,185	16	4
Bisphenol A	576	471	455	449	293	370	320	255	187	202	182	22	12
1,3-Butadiene[d]	3,552	3,515	3,259	3,507	2,597	3,682	3,644	3,527	3,340	3,101	3,123	1	1
***n*-Butanol**	732	756	660	625	490	558	519	590	466	468	405	−3	6
Caprolactam	945	919	867	780	713	668	656	640	575	na	na	3	na
Carbon disulfide	447	476	505	508	479	782	777	768	753	721	799	−6	−6
Carbon tetrachloride	704	737	809	857	906	1,163	1,047	997	1,009	1,011	883	−4	−2
Cumene	3,995	3,380	2,644	2,716	2,003	2,906	2,665	2,293	2,144	1,983	1,687	18	9
Cyclohexane	2,412	2,332	2,265	2,187	1,734	2,352	2,123	2,298	1,748	1,841	2,232	3	1
Diisodecyl phthalate	177	171	161	143	106	147	171	153	136	123	137	4	3
Dodecylbenzene[e]	627	526	526	529	495	533	498	524	550	553	529	19	2
Ethanol, synthetic	1,308	1,267	1,339	1,496	1,429	1,618	1,962	1,851	1,630	1,957	2,361	3	−6
Ethanolamines[f]	421	362	308	286	258	307	293	284	259	264	255	16	5
Ethyl chloride	572	540	612	669	575	662	660	576	620	678	679	6	−2
Ethylbenzene[g]	8,530	8,385	8,312	5,770	4,822	6,048	5,688	5,676	4,984	4,827	4,907	2	6
Ethylene	29,187	25,955	25,172	22,475	20,499	23,891	22,329	20,852	18,450	18,089	16,436	12	6
Ethylene dichloride	11,821	11,001	10,997	8,042	7,977	9,165[h]	9,293[h]	7,809	7,558	7,460	6,037	7	7
Ethylene glycol	4,597	3,904	3,675	3,335	3,809	3,341	3,278	3,761	3,070	3,038	2,571	18	6
Ethylene oxide	5,277	5,012	4,364	4,184	4,467	4,200[i]	4,167	3,962	3,598	3,865	3,408	5	4
2-Ethylhexanol	318[j]	420	493	450	387	395	402	526	287	457	405	−24	−2
Formaldehyde, 37%	6,446	6,381	6,046	5,449	4,558	5,764	6,424	5,652	4,522	4,427	4,398	1	4
Isopropyl alcohol	1,968	1,730	1,888	1,936	1,521	1,939	1,835	1,790	1,674	1,919	2,014	14	0
Maleic anhydride	354	341	294	264	216	290	282	274	229	215	201	4	6
Methanol, synthetic	7,411	6,443	6,453	6,242	5,176	6,878	7,064	6,472	4,950	4,932	4,206	15	6
Methyl chloride	449	454	476	378	366	493[h]	544[h]	454	437	423	403	−1	1
Methyl ethyl ketone	649	661	512	428	425	506	541	509	484	480	484	−2	3
Methyl chloroform	710	644	635	631	459	592	548	441	375	366	324	10	8
Methylene chloride	635	570	478	538	497	609	520	471	401	402	366	11	6
Perchloroethylene	770	725	614	669	679	734	706	734	705	707	635	6	2
Phenol, synthetic[k]	2,946	2,682	2,338	2,121	1,746	2,298	2,241	2,052	1,744	1,708	1,636	10	6
Phthalic anhydride	1,039	978	926	902	702	977	1,023	933	794	734	760	6	3
Propylene[c]	14,298[l]	13,014[l]	13,328[l]	10,030[l]	8,709[l]	10,475	9,884[m]	8,472[m]	6,891[m]	6,641[m]	7,235[m]	10	7
Propylene glycol	617	547	489	517	391	510	502	563	421	428	461	13	3
Propylene oxide	2,249	2,047	1,866	1,823	1,524	1,756	1,753	1,520	1,194	1,179	1,177	10	7
Styrene, monomer	7,484	7,186	6,867	6,301	4,673	5,956	5,975	5,941	4,682	4,335	4,648	4	5
Terephthalic acid, dimethyl ester[n]	4,264	5,954	5,410	5,051	4,614	4,262	2,564[o]	4,405[p]	3,574	2,989	2,750	22	10
Toluene, mg[b,c]	1,637	1,054	1,018	999	705	922	958	916	876	830	759	55	8
Vinyl acetate	1,983	1,692	1,586	1,481	1,290	1,403	1,503	1,211	931	803	729	17	11
Vinyl chloride	7,544	6,941	5,986	5,677	4,196	5,621	5,351	5,089	4,336	4,040	3,736	9	7
***o*-Xylene**	1,075	1,013	985	854	703	1,056	1,068	832	785	799	850	6	2
***p*-Xylene**	4,175	3,516	3,172	2,911	2,484	2,707	2,326	2,208	1,662	1,590	1,628	19	10

a Preliminary figures. **b** Tar distillers not included to avoid disclosing individual company data; includes material for use in blending motor fuels. **c** All grades. **d** Rubber grade. **e** Includes straight-chain dodecylbenzene, tridecylbenzene, and other straight-chain alkylbenzenes. **f** Mono-, di-, and triethanolamines. **g** Does not include ethylbenzene produced and consumed in continuous-process styrene manufacture. **h** Production figure may be too low, because some methyl chloride and ethylene dichloride were produced but not separated or accurately measured by some producers. **i** Approximate figure. **j** By weight. **k** Does not include data for coke ovens and gas retort ovens. **l** Includes refinery propylene. **m** Includes data for propane-propylene mixture. **n** Includes both the acid and its dimethyl ester (DMT), without double counting; acid figures multiplied by 1.16 to convert to equivalent DMT. **o** Includes only dimethyl ester and not acid. **p** Figure may be too high because of possible double counting of some acid and ester. **na** = not available. **Source:** International Trade Commission

INORGANICS: Growth strongest last year for chlorine, caustic soda, and phosphoric acid

Thousands of tons unless otherwise noted	Production											Annual change	
	1979[a]	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1978–79	1969–79
Aluminum sulfate[b]	1,223	1,309	1,255	1,202	1,146	1,257	1,233	1,193	1,127	1,191	1,253	−7%	0%
Ammonia,[c,d] 100%	18,067	17,188	17,765	16,716	16,419	15,733	15,208	15,169	14,538	13,824	12,769	5	4
Ammonium nitrate,[e] 100%	7,798	7,210	7,177	7,186	7,088	7,542	7,235	6,863	6,635	6,456	5,891	8	3
Ammonium sulfate,[d,f] 100%	na	2,449	2,264	2,010	2,106	2,120	1,987	1,858	1,821	1,894	1,916	na	na
Carbon dioxide[g]	3,153	3,001	2,610	2,064	1,850	1,804	1,566	1,610	1,344	1,135	1,167	5	10
Chlorine gas[h]	12,102	11,052	10,573	10,378	9,167	10,753	10,402	9,854	9,352	9,764	9,376	10	3
Hydrochloric acid,[i] 100%	2,971	2,791	2,668	2,542	2,009	2,470	2,534	2,360	2,099	2,014	1,911	6	5
Hydrogen,[j,k] bcf, 100%	96	91	85	82	74	82	65	59	56	60	65	5	4
Nitric acid,[l] 100%	8,555	7,934	7,987	7,791	7,527	8,120	8,398	7,981	7,638	7,603	7,223	8	2
Nitrogen gas,[j,m] bcf, 100%	414	383	328	289	252	243	227	194	168	151[n]	133[n]	8	12[o]
Oxygen,[j,m] bcf, 100%	429	430	392	388	353	390	389	352	319	284[n]	276[n]	0	4[o]
Phosphoric acid, 100% P_2O_5	10,185	9,359	8,745	7,949	7,677	7,213	6,927	6,712	5,970	5,683	5,435	9	6
Phosphorus[p]	461	441	430	437	450	524	526	541	545	597	623	5	−3
Sodium hydroxide, 100%	12,388	11,326	11,000	10,516	9,635	11,189	10,734	10,216	9,667	10,141	9,917	9	2
Sodium phosphate[q]	756	739	717	724	770	903	967	1,033	1,040	1,208	1,215	2	−5
Sodium silicate[r]	779	796	760	747	724	770	723	661	636	628	657	−2	2
Sodium sulfate,[s] 100%	1,175	1,168	1,199	1,232	1,227	1,348	1,437	1,327	1,356	1,373	1,475	1	−2
Sulfuric acid,[t] 100%	41,973	41,088	38,337	34,878	32,360	33,936	31,949	31,183	29,035	29,525	29,537	2	4
Titanium dioxide,[u] 100%	725	701	687	713	603	787	785	693	678	655	644	3	1
Urea, 100%	6,749[v]	6,506[v]	5,072	4,498	3,799	3,789	3,543	3,467	3,125	3,119	2,972	4	9

a Preliminary. **b** Commercial, 17% Al_2O_3; includes municipalities except in 1979. **c** Synthetic anhydrous. **d** Excludes by-product ammonia liquor and ammonium sulfate. **e** Original solution. **f** Synthetic and noncoke by-product. **g** Solid, liquid, and gas; excludes quantities produced and consumed in plants making soda ash or urea, and quantities produced and transferred to other plants for further processing. **h** Includes quantities liquefied for use, storage, or shipment. **i** Includes anhydrous hydrochloric acid production. **j** High- and low-purity gas. **k** Liquid and gas; excludes amounts vented and used as fuel, and amounts produced in petroleum refineries for captive use. **l** Includes unspecified amounts of nitric acid produced but not withdrawn from the system. **m** Excludes amounts produced and consumed in making synthetic ammonia or ammonia derivatives. **n** High-purity gas only. **o** Annual change for 1971–79. **p** Elemental, white (yellow), and red. **q** Tripolyphosphate (100% $Na_5P_3O_{10}$). **r** Soluble silicate glass (water glass), solid and liquid (anhydrous); excludes amounts produced and consumed in making meta-, ortho-, and sesquisilicates. **s** Anhydrous, high and low purity, and Glauber's salt. **t** Gross (new and fortified). **u** Composite and pure. **v** Data for 1978 and 1979 collected by Department of Commerce; previous data collected by International Trade Commission. **na** = not available. **Sources:** Department of Commerce, International Trade Commission

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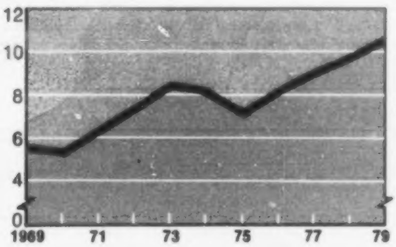
MAN-MADE FIBERS:

U.S. output tops 10 million lb for first time

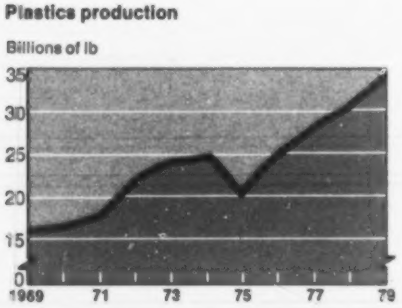
Man-made fibers production

Billions of lb



Millions of lb	Production											Annual change	
	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1978–79	1969–79
CELLULOSIC FIBERS													
Acetate[a]	324	308	290	298	313	382	462	429	476	498	498	5%	−4%
Rayon	606	597	598	543	436	817	895	965	915	875	1078	2	−6
NONCELLULOSIC FIBERS													
Acrylic[b]	761	726	709	621	525	631	742	626	545	492	533	5	4
Nylon[c]	2,720	2550	2326	2075	1857	2124	2175	1974	1595	1355	1411	7	7
Olefins[d]	759	692	635	577	497	531	492	416	322	262	269	10	11
Polyester	4,178	3800	3642	3340	2995	2926	2888	2328	1142[e]	1022[e]	939[e]	10	na
Textile glass	1,012	923	787	676	546	683	688	572	468	467	501	10	7
Other	18[f]	16[f]	16[f]	14[f]	12[f]	12[f]	13[f]	11[f]	688[g]	455[g]	376[g]	12	na
TOTAL	**10,378**	**9611**	**9002**	**8144**	**7181**	**8105**	**8354**	**7322**	**6152**	**5427**	**5606**	**8%**	**6%**

a Includes diacetate and triacetate; excludes production for cigarette filtration. **b** Includes modacrylic. **c** Includes aramid. **d** Includes olefin yarn and monofilaments, and olefin and vinyon staple and tow. **e** Does not include yarn and monofilaments. **f** Includes only yarn and monofilaments; yarn is chiefly saran and spandex. **g** Includes only yarn and monofilaments; yarn includes polyester, anidex, saran, spandex, vinyon, and TFE fluorocarbon. **na** = not available. **Source:** Textile Economics Bureau



PLASTICS: Polyolefins lead U.S. production to a new peak

Millions of lb[a]	Production											Annual change	
	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1978-79	1969-79[b]
THERMOSETTING RESINS													
Epoxy[c]	361	299	261	244	198	249	223	184	165	165	166	21%	8%
Polyester[d]	1,147	1,209	1,061	1,042	834	911	1,051	933	730	569	688	−5	5
Urea	1,367	1,122	963	821	690	835	867	739	636	746	817	22	7
Melamine	200	202	200	186	115	164	170	171	168			−1	
Phenolic[e]	1,781	1,617	1,458	1,340	1,051	1,335	1,387	1,453	1,194	1,186	1,181	10	4
TOTAL	**4,857**	**4,448**	**3,943**	**3,631**	**2,888**	**3,494**	**3,698**	**3,481**	**2,893**	**2,666**	**2,852**	**9%**	**5%**
THERMOPLASTIC RESINS													
Polyethylene													
Low density[f]	7,793	7,111	6,471	5,813	4,743	5,973	5,803	5,274	4,458	4,240	3,880	10	7
High density[g]	5,010	4,201	3,652	3,125	2,468	2,837	2,637	2,325	1,924	1,604	1,610	19	12
Polypropylene	3,840	3,074	2,747	2,632	1,902	2,249	2,162	1,726	1,288	1,031	1,090	25	13
Polystyrene													
Acrylonitrile-butadiene-styrene	1,191	1,134	1,069	988	642	857	877	810	686[h]	566	584	5	8
Styrene-acrylonitrile	124	120	115	113	109	109	121	99	77[h]			3	
Solid (straight and rubber modified)	4,005	3,823	3,446	3,195	2,662	3,364	3,322	3,139	2,553	2,371	2,205	5	6
Styrene-butadiene copolymers and other styrene resins	916	878	813	756	585	679	703	624	433	611	555	4	5
Polyamide, nylon type	327	275	254	247	135	204	205	157	110[h]	91	92	19	14
Polyvinyl alcohol	148	127	119	123	118	142	96	62	58[h]	45	57	17	10
Polyvinyl chloride and copolymers[i]	6,119	5,723	5,253	4,716	3,648	4,850	4,562	4,259	3,471	3,115	3,032	7	7
Other vinyl resins[j]	220	197	197	225	187	209	199	194	167[h]	170	171	12	3
TOTAL	**29,693**	**26,663**	**24,136**	**21,933**	**17,199**	**21,473**	**20,687**	**18,669**	**15,225**	**13,850**	**13,276**	**11%**	**8%**

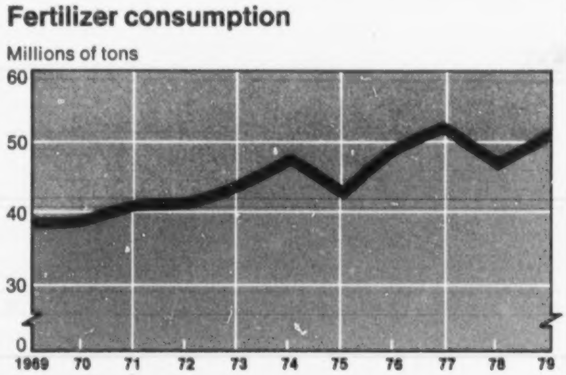
a Dry weight basis. b Annual change calculated for 1969–79 is approximate, because figures from Society of the Plastics Industry for 1979 and International Trade Commission for 1969 are not completely comparable. c Unmodified. d Unsaturated. e Includes other tar acid resins. f 0.940 density and below. g Density above 0.940. h Figure from International Trade Commission. i Dry resin content. j Includes polyvinyl butyral, polyvinyl formal, and polyvinylidene chloride. **Sources:** Society of the Plastics Industry, for years 1971 to 1979, and International Trade Commission for previous years

SYNTHETIC RUBBER: Total output up slightly despite small decline for SBR last year

Thousands of metric tons	Production											Annual change	
	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1978-79	1969-79
Styrene-butadiene rubber[a]	1378	1395	1395	1333	1179	1465	1536	1500	1440	1352	1425	−1%	0%
Polybutadiene	397	378	361	352	290	310	337	300	258	284	267	5	4
Butyl	194	154	149	125	80	165	160	131	108	120	132	26	4
Nitrile	75	73	70	73	55	88	84	74	66	68	70	3	1
Polychloroprene	183	161	165	165	144	163	na	na	na	na	na	14	na
Ethylene-propylene	175	174	158	130	84	126	120	91	61	64	76	1	9
Polyisoprene	125[b]	138[b]	62	74	61	92	119	134	119	122	111	−9	0[e]
Other[c]			56	51	47	88	270[d]	227[d]	226[d]	221[d]	204[d]		
TOTAL	**2528**	**2475**	**2418**	**2304**	**1941**	**2498**	**2626**	**2457**	**2277**	**2232**	**2286**	**2%**	**1%**

a Excludes high-styrene latex (more than 45% styrene). b Separate polyisoprene production figure unavailable; only one producer in 1978 and 1979, and figures withheld to avoid disclosing company data. c Excludes polyurethane rubber. d Includes polychloroprene (neoprene). e Annual change for 1969–79 calculated by comparing polychloroprene plus polyisoprene and other in 1979 with polyisoprene and other (including polychloroprene) in 1969. na = not available. **Sources:** Rubber Manufacturers Association, Department of Commerce

Fertilizer use rebounded last year to almost match 1977's peak



Note: Years ending June 30. **Source:** Department of Agriculture

FERTILIZERS: Sharp increases in nitrogen and phosphate exports spur U.S. production . . .

												Annual change	
Thousands of tons	**1979**	**1978**	**1977**	**1976**	**1975**	**1974**	**1973**	**1972**	**1971**	**1970**	**1969**	**1978–79**	**1969–79**
NITROGEN (N)													
Domestic production	11,229	10,466	10,789	10,572	9343	10,094	9447	8971	8924	8321	7869	7%	4%
Imports	2,159	1,866	1,842	1,218	1198	1,068	882	843	929	855	690	16	12
Exports	2,468	1,778	1,251	1,239	1115	1,269	1508	1032	1077	1328	1594	39	4
Domestic supply	10,920	10,554	11,380	10,551	9426	9,893	8821	8782	8776	7848	6965	3	5
PHOSPHATE (P_2O_5)													
Domestic production	9,432	8,245	7,793	7,199	7230	6,869	6387	6150	5736	5520	5096	14	6
Imports	236	229	245	221	274	315	312	326	283	273	183	3	3
Exports	3,848	3,290	2,501	2,175	1860	1,581	1422	1102	898	845	995	17	14
Domestic supply	5,820	5,184	5,537	5,245	5644	5,603	5277	5374	5121	4948	4284	12	3
POTASH (K_2O)													
Domestic production	2,519	2,176	2,584	2,313	2287	2,604	2690	2432	2490	2430	2742	16	−1
Imports	5,083	4.948	4,955	3,910	3847	4,114	3192	3088	2510	2646	1977	3	10
Exports	999	1,003	994	911	848	947	922	657	620	681	787	0	2
Domestic supply	6,603	6,121	6,545	5,312	5286	5,771	4960	4863	4380	4395	3932	8	5

. . . as do more-than-average increases in consumption on the part of U.S. farmers

	Consumption											Annual change	
Thousands of tons	**1979**	**1978**	**1977**	**1976**	**1975**	**1974**	**1973**	**1972**	**1971**	**1970**	**1969**	**1978–79**	**1969–79**
TYPE													
Mixed fertilizer	23,639	22,110	24,099	22,958	20,647	24,067	22,547	21,511	21,513	20,961	21,234	7%	1%
Primary nutrient material	25,313	23,511	24,999	23,935	19,959	20,897	19,275	18,385	18,389	17,331	16,380	8	4
Secondary and micronutrients	2,080	1,877	2,525	2,296	1,878	2,130	1,466	1,310	1,216	1,297	1,334	11	5
TOTAL	**51.031**	**47.497**	**51.624**	**49,189**	**42,484**	**47,094**	**43,288**	**41,206**	**41,118**	**39,589**	**38,949**	**7%**	**3%**
PRIMARY NUTRIENT CONTENT													
Nitrogen (N)	10,643	9,965	10,647	10,412	8,601	9,157	8,295	8,022	8,134	7,459	6,958	7	4
Phosphate (P_2O_5)	5,544	5,096	5,630	5,228	4,507	5,099	5,085	4,864	4,803	4,574	4,656	9	2
Potash (K_2O)	6,216	5,526	5,834	5,210	4,453	5,083	4,649	4,327	4,231	4,036	3,892	12	5
TOTAL	**2,403**	**20,587**	**22,111**	**20,849**	**17,561**	**19,338**	**18,029**	**17,213**	**17,168**	**16,068**	**15,515**	**9%**	**4%**

Note: Years ending June 30. **Source:** Department of Agriculture

SECTION 2 FINANCES OF THE U.S. CHEMICAL INDUSTRY

Higher prices give boost to sales and profits

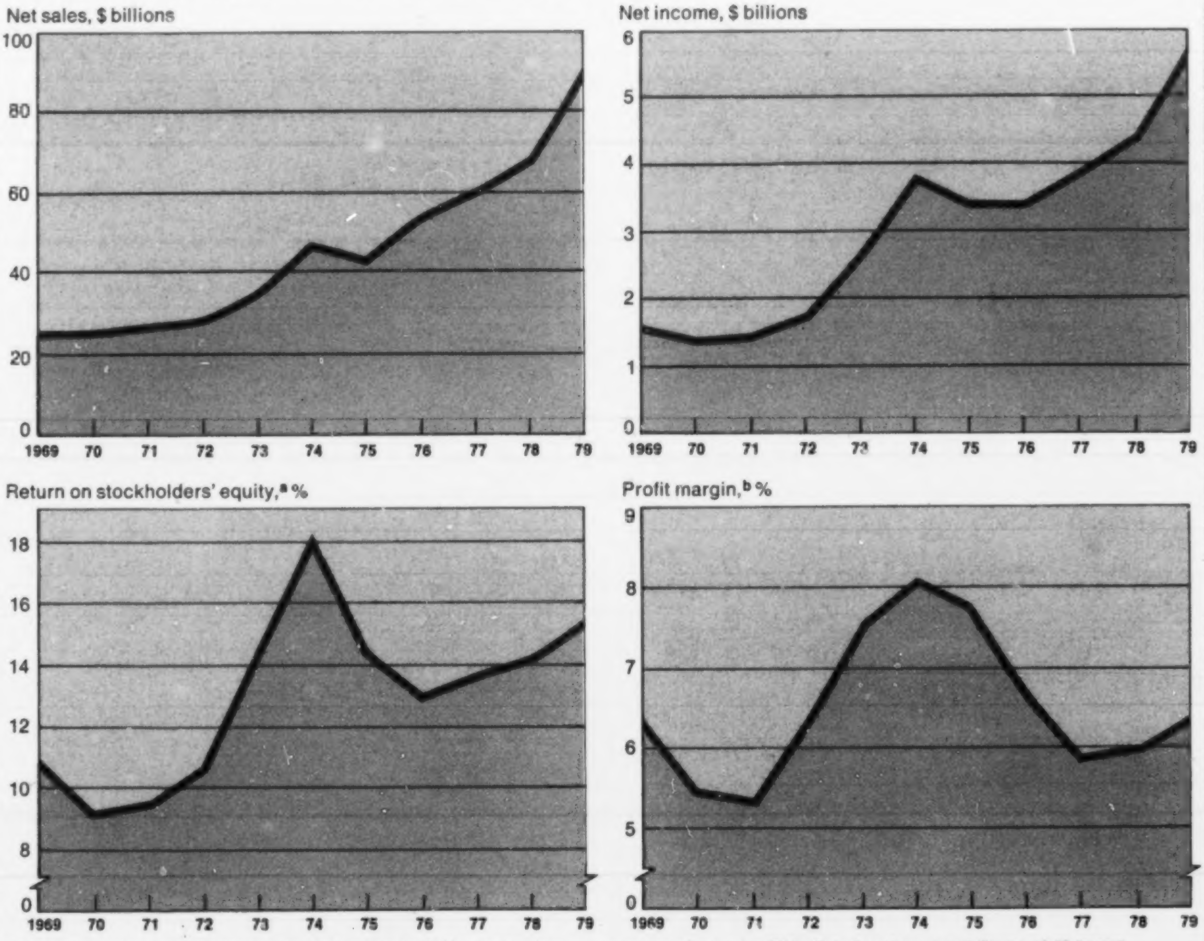
Last year turned out to be considerably better, financially, for chemical companies than most industry analysts had expected even 12 months ago. Sales in the U.S. and abroad expanded a resounding 22% for the major producers of industrial chemicals.

But the gain owes more to higher price tags on chemical products (up 17% on the year for industrial chemicals and 18% for plastics materials) than to higher physical volume, as producers tried to pass sharply increased expenses for feedstocks and energy supplies along to their customers.

Chemical companies also managed to bring a bigger share of their sales down to the bottom line; profits soared nearly 30%, the best increase in the past five years. More to the point, profitability also improved. Profit margins and return on equity remain well below what they had been in the mid-1970's, but at least the trend was upward.

But perhaps not for long. Although the first quarter of 1980 was strong, the gathering U.S. recession is sure to squeeze profits severely during the rest of the year.

Hefty gains in chemical companies' sales and earnings last year brought some improvement in profitability



a After-tax earnings as percentage of stockholders' equity. b After-tax earnings as percentage of net sales. **Note:** Data based on annual figures of 40 largest industrial chemical companies.

TOP 50 CHEMICAL PRODUCERS: Petroleum refiners score some big gains in chemicals

Rank		Company	Chemical sales 1979 ($ millions)	Change from 1978	Total sales 1979 ($ millions)	Chemical sales as % of total sales	Industry classification	TOTAL COMPANY Net income ($ millions)	Profit margin[b]			Return on stockholders' equity[c]		
1979	1978[a]								Per cent 1979	Rank 1979	Rank 1978	Per cent 1979	Rank 1979	Rank 1978
1	1	**Du Pont**	$9700	20%	$12,572	77%	Basic chemicals	$ 938.9	7.5%	13	10	18.0%	14	9
2	2	**Dow Chemical**	6634	33	9,255	72	Basic chemicals	783.9	8.5	7	8	20.1	7	6
3	5	**Exxon**	5807	44	79,106	7	Petroleum	4295.2	5.4	29	32	19.0	11	19
4	3	**Union Carbide**	5300[d]	14	9,177	58	Basic chemicals	556.2	6.1	22	23	13.8	34	35
5	4	**Monsanto**	5215	21	6,193	84	Basic chemicals	331.0	5.3	30	16	11.9	40	32
6	7	**Celanese**	3010	23	3,146	96	Basic chemicals	141	4.5	37	35	13.6	36	31
7	6	**W. R. Grace**	2619[d]	2	5,267	50	Specialty chemicals	222.6	4.2	38	37	14.2	33	29
8	8	**Shell Oil**	2599	37	14,431	18	Petroleum	1125.6	7.8	11	11	16.1	23	23
9	11	**Gulf Oil**	2437[d]	43	23,910	10	Petroleum	1322	5.5	26	34	15.2	28	39
10	9	**Allied Chemical**	2150	16	4,332	50	Basic chemicals	175.6	4.1	39	22	14.3	32	30
11	10	**Hercules**	2039	19	2,345	87	Basic chemicals	172.5	7.4	14	20	18.2	13	26
12	12	**Occidental Petroleum**	1994[d]	20	9,555	21	Petroleum	561.6	5.9	26	49	33.0	1	48
13	15	**Standard Oil (Ind.)**	1958	50	18,610	11	Petroleum	1506.6	8.1	9	13	18.0	15	14
14	20	**Phillips Petroleum**	1693	52	9,503	20	Petroleum	891.1	9.4	5	5	20.9	6	4
15	13	**American Cyanamid**	1685[d]	18	3,187	53	Basic chemicals	168.5	5.3	31	19	12.5	39	28
16	21	**Atlantic Richfield**	1662	52	16,234	10	Petroleum	1165.9	7.2	15	14	19.1	10	12
17	14	**Eastman Kodak**	1576	17	8,028	20	Photographic equipment	1000.8	12.5	2	2	18.6	12	5
18	16	**Stauffer Chemical**	1496	15	1,526	98	Basic chemicals	136.0	8.9	6	6	16.0	25	8
19	19	**Rohm & Haas**	1479	30	1,590	93	Basic chemicals	95.5	6.0	23	31	15.0	29	38
20	31	**Tenneco**	1470[d]	82	11,209	13	Petroleum	571	5.1	32	21	15.4	26	17
21	17	**Borden**	1454[d]	16	4,313	34	Dairy products	134.0	3.1	42	38	11.3	41	25
22	18	**Ethyl Corp.**	1440[d]	17	1,657	87	Specialty chemicals	97.5	5.9	25	17	16.1	24	13
23	23	**Mobil**	1325	32	44,721	3	Petroleum	2007.2	4.5	36	39	19.1	9	27
24	22	**Diamond Shamrock**	1234	23	2,357	52	Basic chemicals	178.1	7.6	12	9	17.5	17	11
25	33	**U.S. Steel**	1207	58	12,929	9	Steel	(293.0)[e]	—	—	—	—	—	—
26	24	**FMC**	1135	14	3,307	34	Farm and construction machinery	151.6	4.6	35	26	13.1	38	21
27	25	**Air Products**[f]	1062	16	1,230	86	Basic chemicals	97.5	7.9	10	12	17.2	18	10
28	37	**Texaco**	1047	53	38,350	3	Petroleum	1759.1	4.6	34	41	16.5	21	42
29	30	**BASF Wyandotte**	1045	28	1,103	95	Basic chemicals	9.7	0.9	48	40	3.7	47	36
30	29	**Standard Oil of Calif.**	1043	26	29,948	3	Petroleum	1784.7	6.0	24	28	19.2	8	20
31	28	**B. F. Goodrich**	1041	21	2,988	35	Rubber products	82.6	2.8	44	42	9.2	44	43
32	26	**Ashland Oil**	1017	15	6,474	16	Petroleum	186.4	2.9	43	45	17.5	16	40
33	27	**PPG Industries**	972	10	3,092	31	Glass products	218.9	7.1	16	27	16.4	22	34
34	38	**American Hoechst**	968	42	1,174	82	Basic chemicals	30	2.6	45	45	na	—	—
35	32	**Mobay Chemical**	955	23	955	100	Basic chemicals	58.1	6.1	21	30	16.8	20	24
36	39	**Union Oil of Calif.**	865	28	7,568	11	Petroleum	500.6	6.6	17	15	16.9	19	15
37	41	**Ciba-Geigy**	844	27	1,320	64	Specialty chemicals	na	na	—	—	na	—	—
38	42	**Williams Cos.**	840	27	1,850	49	Agricultural chemicals	69.5	3.8	41	48	9.3	43	47
39	34	**Olin**	823	15	1,778	46	Basic chemicals	71.2	4.0	40	36	9.6	42	41
40	35	**Reichhold Chemicals**	794	14	875	91	Basic chemicals	12.2	1.4	47	47	6.2	46	45
41	42	**Conoco**	792	32	12,648	6	Petroleum	815.4	6.3	19	29	21.6	5	16
42	36	**International Minerals**[g]	780	12	1,475	53	Agricultural chemicals	120.8	8.2	8	7	15.3	27	7
43	40	**National Distillers**	773	16	2,115	37	Alcoholic beverages	135.8	6.4	18	24	13.3	37	37
44	44	**Lubrizol**	725	24	725	100	Specialty chemicals	90.8	12.5	1	1	24.2	2	2
45	48	**Dow Corning**	610	27	610	100	Specialty chemicals	71.5	11.7	3	3	21.8	4	3
46	50	**Borg-Warner**	595	26	2,717	22	Automobile equipment	155.6	5.7	27	18	14.4	31	18
47	49	**Nalco Chemical**	579	22	579	100	Specialty chemicals	63.3	10.9	4	4	24.2	3	1
48	46	**Akzona**	576	11	1,012	57	Basic chemicals	25.6	2.5	46	43	7.9	45	44
49	47	**Pennwalt**	562	17	1,079	52	Basic chemicals	50.0	4.6	33	25	13.7	35	22
50	45	**NL Industries**	537	1	1,810	30	Basic chemicals	114.6	6.3	20	33	14.7	30	33

a Revised. **b** Net income as a percentage of net sales. **c** Net income as a percentage of net worth. **d** Chemical sales include significant amounts of nonchemical products, such as fabricated plastics, coatings, metals, minerals, and the like. **e** Deficit. **f** For the year ended Sept. 30. **g** For the year ended June 30. **na** = not available. **Note:** Industry classifications are based largely, but not entirely, on the federal Enterprise Standard Industrial Classification system.

SHIPMENTS: Chemical sales totaled close to $150 billion last year

$ Billions	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	Annual change 1978–79	Annual change 1969–79
All manufacturing industries	$1692.0	$1496.6	$1330.1	$1185.7	$1039.4	$1017.9	$875.4	$756.5	$671.1	$634.0	$642.5	13%	10%
Chemicals and allied products	149.2	126.4	113.9	104.1	89.7	83.7	65.0	57.4	50.9	48.5	47.4	18	12
Industrial chemicals[a]	51.8	42.4	39.1	35.6	29.4	26.6	19.0	16.6	14.9	14.5	14.2	22	14
Drugs, soap, and toiletries	40.2	34.1	30.5	27.8	24.3	22.2	19.3	17.8	15.9	15.1	14.0	18	11
Petroleum and coal products	134.0	103.6	95.7	82.3	69.5	58.9	34.9	28.7	26.9	24.9	24.4	29	19
Rubber and plastics products, nec	44.7	39.9	37.0	31.8	27.2	27.9	24.4	20.9	17.8	16.1	16.3	12	11
Paper and allied products	66.0	57.7	52.4	48.2	41.7	41.8	32.8	28.3	25.5	24.8	24.4	14	10

[a] Excluding pigments. **nec** = not elsewhere classified. **Source:** Department of Commerce

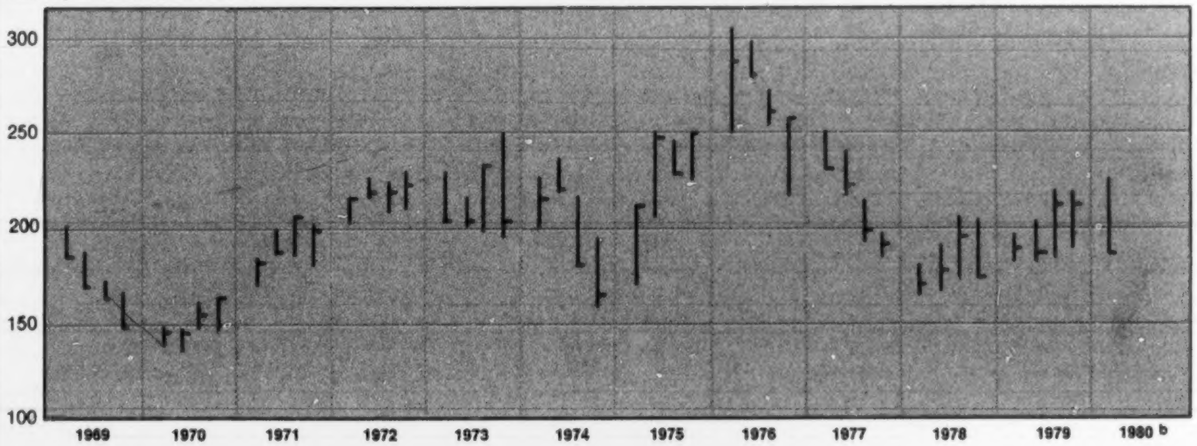
PRICES: Industrial chemicals and plastics ring up sharp increases

Producer price indexes,[a] 1967 = 100	Annual average 1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	Annual change 1978–79	Annual change 1969–79
All commodities	235.6	209.3	194.2	183.0	174.9	160.1	134.7	119.1	114.0	110.4	106.5	13%	8%
Industrial commodities	236.5	209.4	195.1	182.4	171.5	153.8	125.9	117.9	114.1	110.0	106.0	13	8
Chemicals and allied products	222.3	198.8	192.8	187.2	181.3	146.8	110.0	104.2	104.1	102.2	99.9	12	8
Industrial chemicals	264.0	225.6	223.9	219.3	206.9	151.7	103.4	101.2	102.0	100.9	100.3	17	10
Prepared paint	204.4	192.3	182.4	174.4	166.9	145.7	122.2	118.0	115.6	112.4	109.1	6	6
Paint materials	241.2	212.7	205.9	189.8	177.2	152.3	113.2	104.1	101.5	101.4	102.1	13	9
Drugs and pharmaceuticals	159.4	148.1	140.5	134.0	126.6	112.7	104.3	103.0	102.4	101.2	99.9	8	5
Fats and oils, inedible	376.7	315.8	279.0	249.9	255.2	338.2	228.3	115.8	133.6	132.8	109.1	19	13
Agricultural chemicals and chemical products	214.4	198.4	187.8	188.4	203.6	137.7	96.6	91.7	92.1	88.5	86.7	8	9
Plastic resins and materials	235.9	199.8	195.7	194.0	180.9	143.8	92.1	88.7	88.7	90.6	90.4	18	10
Other chemicals and allied products	191.8	181.8	175.7	170.7	168.6	147.5	118.1	113.5	112.0	108.6	104.2	6	6
Rubber and plastic products	194.3	174.8	167.6	159.2	150.2	136.2	112.4	109.3	109.1	108.3	105.3	11	6

[a] Formerly called "wholesale price indexes." **Source:** Department of Labor

Chemical stocks have made little progress during the past couple of years

Stock price index, 1954 = 100[a]



[a] C&EN weighted stock price index of Allied Chemical, American Cyanamid, Celanese, Dow Chemical, Du Pont, Monsanto, and Union Carbide; weighted according to number of shares outstanding for each company. b First quarter.

INDUSTRY BALANCE SHEET: Chemical firms' current liabilities are sharply higher

Industrial chemicals and synthetics

	1979	1978	
Assets	($ billions)		**Change**
Current assets:			
Cash and time deposits	$ 1.20	$ 0.99	22%
Marketable securities	0.90	0.91	−1
Receivables	10.79	9.56	13
Inventories	9.23	8.24	12
Other current assets	1.75	1.34	30
Total	**23.87**	**21.03**	**13**
Fixed assets:			
Plant, property, and equipment	57.97	53.42	9
Less: accumulated depreciation and depletion	28.22	26.13	8
Net fixed assets	**29.76**	**27.29**	**9**
Other assets:			
Investments, intangibles, etc.	**11.20**	**9.25**	**21**
TOTAL ASSETS	**$64.82**	**$57.57**	**13%**

Source: Federal Trade Commission

	1979	1978	
Liabilities and stockholders' equity	($ billions)		**Change**
Current liabilities:			
Accounts payable	$ 5.02	$ 4.26	18%
Short-term loans	1.60	1.07	50
Income taxes	1.15	1.13	1
Current portion of long-term debt	0.60	0.46	32
Other current liabilities	4.77	3.26	46
Total	**13.14**	**10.18**	**29**
Long-term debt	**14.64**	**13.65**	**7**
Deferred taxes and other noncurrent liabilities	**4.81**	**4.21**	**14**
Minority interest	**0.29**	**0.23**	**26**
TOTAL LIABILITIES	**$32.87**	**$28.27**	**16%**
Stockholders' equity:			
Capital stock and other capital	9.37	9.18	2
Retained earnings	23.32	20.81	12
Less: Treasury stock	0.74	0.70	7
TOTAL STOCKHOLDERS' EQUITY	**$31.95**	**$29.29**	**7%**
TOTAL LIABILITIES AND STOCKHOLDERS' EQUITY	**$64.82**	**$57.57**	**13%**

DEBT RATIOS: Changes have been slight for the past five years

$ Billions	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969
INDUSTRIAL CHEMICALS AND SYNTHETICS											
Long-term debt	$14.6	$13.6	$12.3	$11.8	$10.2	$7.8	$7.2	$7.6	$7.6	$7.0	$6.4
Stockholders' equity	$32.0	$29.3	$26.3	$25.0	$22.8	$20.5	$18.7	$18.5	$17.5	$16.2	$15.6
Debt ratio[a]	31.4%	31.8%	31.9%	32.0%	30.8%	27.6%	27.8%	29.2%	30.3%	30.1%	29.2%
DRUGS											
Long-term debt	$3.0	$2.8	$2.6	$2.4	$2.3	$1.7	$1.3	$1.4	$0.9	$1.2	$0.9
Stockholders' equity	$13.9	$12.1	$10.9	$10.3	$9.3	$8.1	$7.5	$7.7	$6.3	$7.1	$6.3
Debt ratio[a]	21.7%	18.7%	19.2%	19.1%	19.6%	17.6%	14.3%	15.0%	12.5%	14.8%	11.9%
CHEMICALS AND ALLIED PRODUCTS											
Long-term debt	$24.6	$23.5	$21.1	$19.4	$16.8	$12.8	$10.7	$11.5	$10.7	$10.0	$9.1
Stockholders' equity	$66.9	$60.8	$54.9	$50.8	$45.7	$40.9	$36.7	$36.1	$32.8	$30.6	$28.6
Debt ratio[a]	26.9%	27.9%	27.8%	27.6%	26.9%	23.8%	22.6%	24.2%	24.6%	24.6%	24.0%
ALL MANUFACTURING											
Long-term debt	$204.0	$182.0	$167.3	$153.6	$145.2	$130.1	$112.9	$118.3	$111.5	$102.5	$90.7
Stockholders' equity	$623.5	$560.8	$511.7	$475.3	$435.5	$408.4	$368.0	$353.1	$327.1	$310.8	$297.1
Debt ratio[a]	24.7%	24.5%	24.6%	24.4%	25.0%	24.2%	23.5%	25.1%	25.4%	24.8%	23.4%

[a] Long-term debt as a percentage of long-term debt plus stockholders' equity. **Note:** Because of sampling changes, numbers over the entire range of years are not strictly comparable. **Source:** Federal Trade Commission

CASH FLOW: Profits rise, debt declines as a source of corporate funds

$ Million, % of total	1979		1978		1977		1976		1975	
SOURCES OF FUNDS										
Net income	$3,800.6	36.3%	$3085.4	33.6%	$2754.0	30.6%	$2855.3	32.9%	$2427.1	29.9%
Depreciation and depletion	3,601.8	34.4	3197.0	34.8	2832.7	31.5	2420.1	27.9	2155.2	26.6
Deferred taxes	426.7	4.1	353.4	3.8	356.6	4.0	373.9	4.3	416.6	5.1
Other internal sources	1,093.3	10.5	929.6	10.1	1214.4	13.5	666.4	7.7	591.0	7.3
Long-term debt	1,209.6	11.6	1544.5	16.8	1609.1	17.9	2219.5	25.6	2333.3	28.8
Stock	321.9	3.1	83.8	0.9	229.9	2.5	142.9	1.6	187.7	2.3
TOTAL	**$10,453.9**	**100.0%**	**$9193.7**	**100.0%**	**$8996.7**	**100.0%**	**$8678.1**	**100.0%**	**$8110.9**	**100.0%**
APPLICATION OF FUNDS										
Dividends	$1,474.2	14.1%	$1317.1	14.3%	$1183.5	13.1%	$1054.9	12.1%	$ 924.1	11.4%
Capital expenditures	5,632.7	53.9	5080.4	55.3	5488.0	61.0	5701.6	65.7	5191.8	64.0
Additions to working capital	1,075.0	10.3	863.1	9.4	520.2	5.8	545.3	6.3	714.3	8.8
Reduction of long-term debt	1,042.4	10.0	878.7	9.5	746.5	8.3	728.3	8.4	742.7	9.2
Other applications	1,229.6	11.7	1054.4	11.5	1058.5	11.8	648.0	7.5	538.0	6.6
TOTAL	**$10,453.9**	**100.0%**	**$9193.7**	**100.0%**	**$8996.7**	**100.0%**	**$8678.1**	**100.0%**	**$8110.9**	**100.0%**

Note: Data are totals for 15 major chemical companies: Allied Chemical, American Cyanamid, Celanese, Diamond Shamrock, Dow Chemical, Du Pont, Ethyl Corp., Hercules, Monsanto, Olin, Pennwalt, Rohm & Haas, Stauffer Chemical, Union Carbide, and Williams Cos. **Source:** Company annual reports

FINANCIAL ANALYSES: Profitability improved for chemical companies last year

	Profit margin[a]	Return on investment[b]	Debt as % of debt plus equity	% total sales abroad[c]	% total assets abroad[d]	Sales per employee[e]	Dividends as % of net income	CAPITAL SPENDING[f] as % of sales	CAPITAL SPENDING[f] as % of net plant	R&D spending as % of sales	Sales as % of assets	Net plant as % of gross plant
SALES OVER $1 BILLION												
Air Products[g]	7.9%	4.9%	34.9%	22.0%	26.1%	$ 84	18.9%	20.0%	26.0%	2.0%	86.6%	60.4%
Akzona	2.5	2.1	41.1	na	na	66	38.3	5.4	13.6	2.5	123.7	47.8
Allied Chemical	4.1	3.3	36.1	25.5	25.8	88	74.3	9.4	18.8	1.6	102.9	57.3
American Cyanamid	5.3	4.6	27.9	36.7	27.1	72	45.2	7.4	18.1	3.9	112.7	56.4
Cabot[g]	6.3	5.9	38.3	25.4	22.7	139	20.6	8.7	24.5	1.6	119.4	56.1
Celanese	4.4	3.5	33.0	21.1	19.9	96	34.8	7.7	21.3	2.9	133.9	39.3
Diamond Shamrock	7.6	6.1	41.6	11.4	12.4	189	43.2	12.8	21.9	1.8	97.5	64.6
Dow Chemical	8.5	6.2	43.9	50.5	52.6	166	34.6	13.7	24.2	2.9	90.3	58.8
Du Pont	7.5	6.0	17.4	31.7	26.0	94	43.5	7.4	23.6	3.3	140.6	35.1
Ethyl Corp.	5.9	6.7	26.8	30.6	14.8	104	30.4	7.9	25.6	1.8	145.0	56.0
B. F. Goodrich	2.8	3.0	37.5	21.1	20.6	71	31.2	4.9	17.2	1.5	143.5	49.8
W. R. Grace	4.2	5.1	34.9	29.9	23.1	64	39.1	9.1	29.3	0.9	141.2	42.8
Hercules	6.2	5.8	21.3	25.6	26.1	96	31.6	7.9	24.1	2.0	133.2	45.4
International Minerals[h]	8.2	6.3	30.0	28.1	16.3	143	41.7	11.8	11.3	0.4	95.9	67.6
Monsanto	5.3	4.1	30.2	33.1	30.7	97	36.6	9.1	20.1	2.8	111.8	51.0
National Distillers	6.4	7.8	25.5	7.4	6.6	135	39.6	2.7	11.1	na	127.1	55.9
Olin	4.0	3.5	28.4	9.0	10.5	82	32.6	9.1	21.1	1.5	121.7	52.6
Pennwalt	4.6	4.9	35.0	22.2	22.3	81	45.0	6.3	22.6	2.2	136.0	51.9
PPG Industries	7.1	5.9	25.9	18.4	14.9	81	27.7	8.1	18.6	2.7	116.7	54.2
Rohm & Haas	6.0	5.4	27.6	36.6	31.5	120	23.8	4.3	13.9	3.4	133.4	43.5
Stauffer Chemical	8.9	5.8	31.5	11.0	10.5	111	34.6	15.7	23.0	2.4	81.3	63.4
Union Carbide	6.1	4.4	30.5	30.3	28.6	79	34.2	9.1	18.6	1.8	104.2	51.1
Williams Cos.	3.8	3.1	43.1	16.0	na	na	39.0	6.1	9.5	na	92.0	74.8
MEDIAN 1979	**6.0%**	**5.1%**	**31.5%**	**25.5%**	**22.3%**	**$96**	**34.8%**	**8.1%**	**21.1%**	**2.0%**	**119.4%**	**52.6%**
MEDIAN 1978	**4.9%**	**4.4%**	**30.9%**	**20.9%**	**21.3%**	**$80**	**40.0%**	**9.1%**	**21.3%**	**2.2%**	**112.0%**	**54.0%**
SALES FROM $160 MILLION TO $1 BILLION												
Beker Industries	5.7	5.3	37.8	13.1	11.5	190	0	2.6	5.3	na	94.3	71.8
Big Three Industries	12.3	7.2	24.9	15.0	10.9	na	26.9	15.6	16.3	na	72.8	72.9
Crompton & Knowles	3.0	4.5	28.2	21.1	21.6	80	39.4	3.3	27.4	1.7	168.9	47.5
Ferro	5.2	6.7	16.7	57.2	54.3	65	12.3	5.6	28.6	0.4	151.5	58.6
First Mississippi[h]	2.6	2.0	38.5	25.4	na	209	72.3	4.2	13.4	na	90.6	43.1
Freeport Minerals	20.8	14.4	24.5	na	na	125	24.2	25.3	35.8	na	71.4	60.2
International Flavors	15.0	13.8	0	71.6	56.5	114	45.9	3.7	13.3	6.6	105.5	62.3
Liquid Air	6.7	4.6	19.5	41.9	37.9	na	58.3	13.7	19.6	1.0	88.4	64.9
Loctite[h]	14.4	18.0	15.1	42.2	51.4	64	15.9	5.4	35.9	2.4	115.2	70.2
Lubrizol	12.2	14.7	2.0	57.8	48.9	190	35.1	6.9	28.2	3.0	142.6	57.6
Mallinckrodt	10.5	11.2	14.9	14.1	na	82	24.1	5.0	15.0	3.3	117.9	63.4
Nalco Chemical	10.9	13.8	3.7	18.9	21.9	140	42.7	6.7	30.8	3.7	157.3	49.8
Petrolite[i]	8.3	8.4	12.8	21.8	20.7	104	39.1	6.4	20.1	3.0	130.4	55.0
Reichhold Chemicals	1.4	2.4	40.7	15.7	19.4	137	66.4	3.0	14.5	na	203.8	62.9
Thiokol	5.4	7.2	3.1	18.6	11.8	60	25.1	6.0	30.4	1.4	154.4	56.4
Texasgulf	17.3	7.7	28.7	37.7	43.4	134	34.3	20.9	15.9	na	47.9	77.0
Witco Chemical	4.4	6.0	32.9	16.6	16.9	na	28.0	5.0	25.1	1.2	170.7	52.4
MEDIAN 1979	**8.3%**	**7.2%**	**19.5%**	**21.5%**	**21.2%**	**$120**	**34.3%**	**5.6%**	**20.1%**	**2.7%**	**130.4%**	**60.2%**
MEDIAN 1978	**7.9%**	**6.1%**	**19.7%**	**21.4%**	**21.3%**	**$96**	**36.0%**	**5.5%**	**20.6%**	**2.7%**	**133.0%**	**60.0%**

a Net income as a percentage of sales. **b** Net income as percentage of current assets plus gross plant. **c** Consolidated sales only. **d** Foreign identifiable assets as percentage of total assets. **e** Thousands of dollars. **f** Actual spending on construction of new facilities and purchase of new equipment and land in consolidated businesses. **g** For fiscal year ended Sept. 30, 1979. **h** For fiscal year ended June 30, 1979. **i** For fiscal year ended Oct. 31, 1979. **na** = not available. **Note:** Net income excludes extraordinary or nonrecurring profits and earnings from discontinued operations, where possible.

INDUSTRY CAPITAL SPENDING: Totals for U.S. plant and equipment projects will rise in 1980

$ Billions	1980[a]	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970
Chemicals	$ 9.28	$ 8.56	$ 7.10	$ 6.83	$ 6.68	$ 6.25	$ 5.69	$ 4.46	$ 3.45	$ 3.44	$ 3.44
Food and beverage	5.28	5.06	4.87	4.18	3.75	3.26	3.25	3.11	2.55	2.69	2.84
Iron and steel	3.53	2.97	2.46	2.67	2.99	3.03	2.12	1.38	1.24	1.37	1.68
Nonferrous metals	3.12	2.61	2.45	2.24	2.16	2.28	2.33	1.67	1.18	1.08	1.24
Paper	6.01	4.88	3.46	3.36	3.27	2.95	2.58	1.86	1.38	1.25	1.65
Petroleum	19.34	16.62	15.50	13.87	11.62	10.51	8.00	5.45	5.25	5.85	5.62
Rubber	1.74	1.80	1.75	1.45	1.10	1.00	1.47	1.56	1.08	0.84	0.94
Stone, clay, and glass	3.02	2.92	2.46	1.99	1.72	1.42	1.44	1.49	1.20	0.85	0.99
Textiles	1.02	1.06	1.04	0.92	0.81	0.66	0.84	0.77	0.73	0.61	0.56
All manufacturing	90.20	78.92	67.62	60.16	52.48	47.95	46.01	38.01	31.35	29.99	31.95

a Estimate. **Source:** Department of Commerce

Big increases also are due for capital spending of U.S. firms outside U.S.

$ Billions[a]	1980[b]	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970
Chemicals and allied products	$ 3.4	$ 3.2	$ 2.5	$ 2.4	$ 2.7	$ 2.5	$ 2.1	$1.4	$1.2	$1.2	$1.2
Food products	1.4	1.3	1.0	0.9	0.7	0.7	0.7	0.6	0.4	0.4	0.4
Metals, primary and fabricated	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.8	0.6	0.6	0.7
Paper and allied products	2.0	1.0	0.8	0.7	0.6	0.7	0.9	0.6	0.5	0.6	0.4
Rubber products	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.2	0.2
All manufacturing	23.9	19.2	14.6	12.7	10.9	11.3	11.6	9.2	7.2	7.0	6.5
Petroleum	15.4	12.0	10.0	9.3	7.9	8.9	7.8	6.4	5.2	5.0	4.0

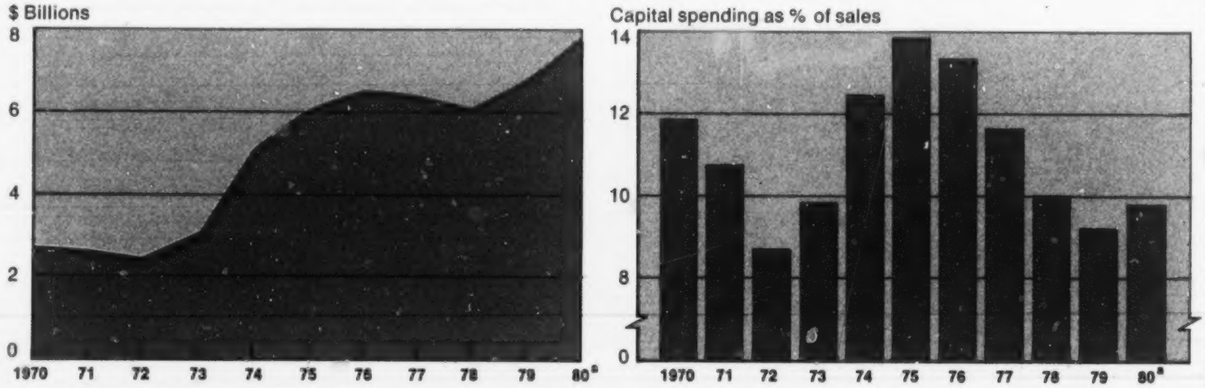
a By majority-owned affiliates of U.S. companies. b Planned. **Source:** Department of Commerce

Capital spending on pollution control projects rises again this year

	1980[a]				1979				1978			
$ Millions	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste
Chemicals	$ 476	$ 218	$ 205	$ 53	$ 440	$ 203	$ 184	$ 53	$ 565	$ 236	$ 286	$ 42
Food and beverage	150	51	83	16	148	61	84	13	172	175	175	22
Iron and steel	638	435	197	6	510	351	154	5	441	290	140	10
Nonferrous metals	286	187	76	23	213	142	58	13	247	189	53	5
Paper	300	[illegible]	125	40	297	133	124	40	239	105	103	31
Petroleum	1536	844	565	127	1386	708	530	147	1294	611	586	98
Rubber	58	39	14	6	62	38	12	12	58	40	12	7
Stone, clay, and glass	176	130	33	13	145	116	22	7	164	109	47	7
All manufacturing	4540	2515	1642	383	3976	2103	1493	381	3951	1992	1652	306

a Planned. **Source:** Department of Commerce

Chemical capital spending rises, but is still low compared with company sales



a Planned. **Sources:** Worldwide data for 20 large U.S. basic chemical companies, C&EN estimates

Although being struck harder and harder this year by a general economic downturn in the U.S., chemical companies are lifting their plans moderately for spending on new plant and equipment. A C&EN survey of 20 leading companies finds that latest company plans add up to a 16% increase in spending for 1980 worldwide over 1979. This follows a 12% gain in 1979 after small declines in outlays the previous two years.

The 16% increase now planned, if it holds up, still will not exceed the rate of inflation very much. And it will be relatively modest in relation to company sales. For 1980, capital spending will be less than 10% of sales for these 20 companies for the second straight year. Historically, spending at a rate of 9 to 10% of sales has marked the low point in capital spending cycles. By contrast, in the previous business cycle, during the boom and bust years of 1974 and 1975, capital spending exceeded 13% of sales.

In the broad U.S. chemicals and allied products industry, capital spending plans already have decelerated this year from a fairly hot pace in 1979. The Commerce Department finds the industry headed for an 8% gain for plant and equipment outlays in the U.S. after a 21% increase in 1979. The jump in 1979 came on the heels of gains of only 4% and 2%, respectively, in 1978 and 1977.

The picture for foreign affiliates of U.S. chemicals and allied products firms has changed even more dramatically. After a 28% spurt in 1979 following a rough plateau since 1975, capital spending abroad will rise merely 6% in 1980, Commerce estimates.

Spending by chemical firms on projects to control pollution seems set for a modest increase in 1980. Initial plans for antipollution spending are up 8% from 1979. Air and water sectors are each ticketed for more than 40% of the total, with the remainder going for solid waste control. However, chemical companies have tended to overstate pollution-control spending plans in initial surveys in recent years. For 1979, for instance, a 3% rise planned initially turned into a 22% drop by the end of the year.

In C&EN's capital spending survey, more than 40% of total spending in 1980 is planned by just three companies—Dow Chemical, Du Pont, and Union Carbide, each with budgets of $1 billion or more. All three are projecting substantial increases in 1980, after boosting spending solidly also in 1979. Dow has kept its spending at $1 billion or more throughout the second half of the 1970's.

CHEMICAL CAPITAL SPENDING: **Leading companies plan largest increase in five years**

$ Millions	1980[a]	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970
Air Products	$ 310	$ 246	$ 200	$ 143	$ 162	$ 151	$ 110	$ 67	$ 42	$ 79	$ 51
Akzona	65[b]	54	42	35	38	51	57	42	43	73	46
Allied Chemical	400	409	502	465	352	314	306	194	128	132	132
American Cyanamid	210[b]	235	251	235	232	204	139	83	72	111	94
Celanese	260	245	248	243	223	208	220	159	128	169	135
Diamond Shamrock	315[b]	257	319	389	334	183	201	103	61	56	53
Dow Chemical	1400	1268	1075	1163	1200	935	890	415	359	365	348
Du Pont	1000	864	714	704	876	1036	1008	781	561	474	499
Ethyl Corp.	115	123	96	89	88	69	75	35	32	24	50
W. R. Grace	600	408	285	275	233	309	303	174	135	98	105
Hercules	185	186	116	127	150	151	217	144	80	53	91
International Minerals	300[b]	174	194	175	165	165	97	22	15	18	14
Monsanto	680	566	480	607	647	528	313	205	168	205	301
Olin	140	161	163	208	166	99	67	78	76	55	60
Pennwalt	65	67	62	46	40	32	43	25	22	23	33
PPG Industries	350	252	261	212	177	176	205	136	98	155	173
Rohm & Haas	100	68	66	79	110	106	106	73	62	85	62
Stauffer Chemical	265[b]	239	201	193	199	199	83	45	35	52	47
Union Carbide	1000	831	688	805	965	862	517	289	244	335	394
Williams Cos.	190	113	132	205	204	271	261	92	38	41	23
TOTAL	**$7950**	**$6836**	**$6095**	**$6398**	**$6561**	**$6049**	**$5218**	**$3162**	**$2399**	**$2603**	**$2711**
ANNUAL CHANGE	**16%**	**12%**	**−5%**	**−2%**	**8%**	**16%**	**65%**	**32%**	**−8%**	**−4%**	**7%**

a Planned. b C&EN estimate. **Note:** Figures are for worldwide spending on construction, equipment, and land in consolidated businesses. Where possible, acquisition costs and investments in nonconsolidated businesses are excluded. **Source:** Company data

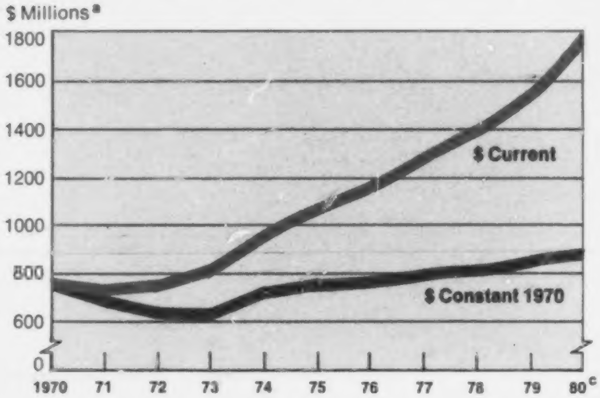
Research and development is getting strong support from U.S. chemical producers in 1980, just as it did in 1979. R&D budgets at 14 leading chemical companies are up 13%. The gain outstrips the likely inflation in R&D costs, estimated by Battelle Columbus Laboratories at 10.7% this year, and so may well lead to further increases in professional staffing.

This year's increase follows one—also of 13%—in 1979. In 1979, too, spending went up faster than R&D inflation, making the job market a good one for scientists and engineers.

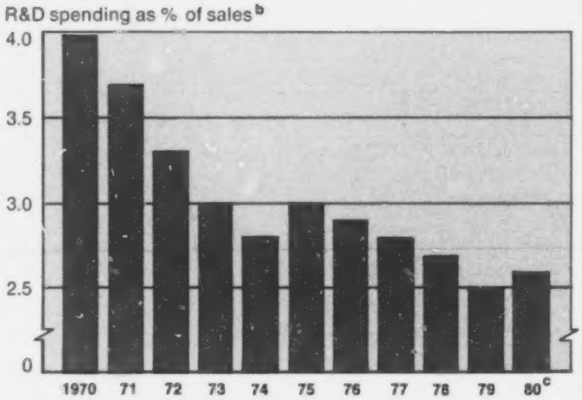
R&D outlays also may capture a larger share of the sales dollar this year as well, rising to 2.6% of sales from 2.5% in 1979. The change is small, but it will be the first increase in the percentage since 1975. Generally, R&D expenditures by chemical companies have been shrinking relative to sales during the past decade as chemical prices have been rising at a faster pace than have R&D costs.

The biggest spenders on R&D in the chemical industry are planning substantial increases in 1980. At Du Pont, biggest of all, a reorganized R&D effort will get an estimated $480 million, up from $415 million in 1979.

R&D outlays in the chemical industry rise slightly ahead of inflation . . .



. . . but remain relatively low as a percentage of total sales



a R&D spending by basic chemical companies. b By basic chemical companies. c Estimate. **Sources:** Worldwide data from 14 U.S. basic chemical companies, Battelle Columbus Laboratories, C&EN estimates

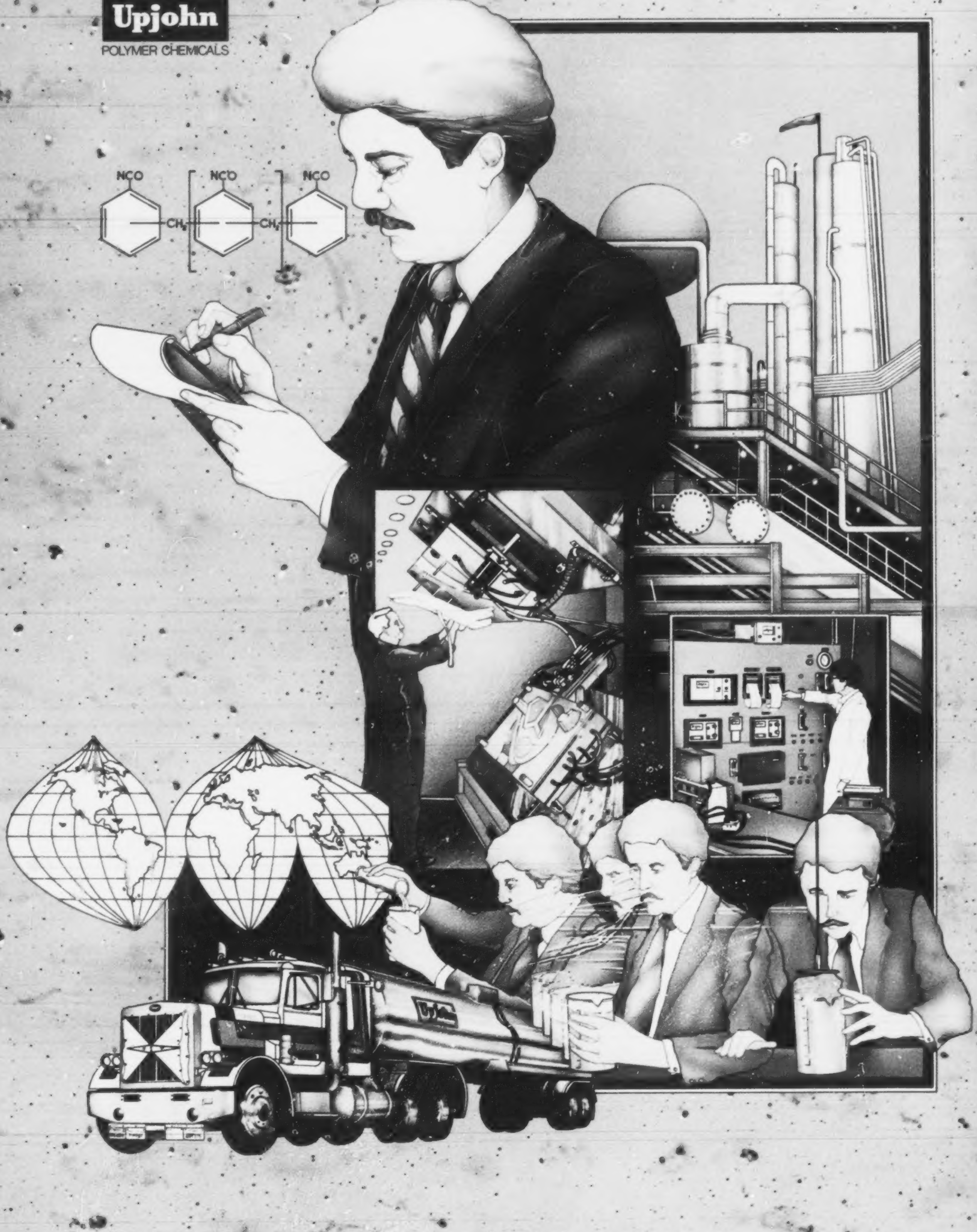
CHEMICAL R&D SPENDING: Large companies are planning some sizable increases in 1980

$ Millions	1980[a]	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970
Air Products	$ 27	$ 23	$ 23	$ 24	$ 19	$ 16	$ 11	$ 8	$ 7	$ 7	$ 5
Akzona	29	25	23	20	18	17	16	13	11	10	7
Allied Chemical	75	70	56	51	40	35	31	29	29	31	29
American Cyanamid	140	124	108	96	83	73	64	52	44	43	47
Celanese	100	92	83	77	70	64	58	49	52	51	55
Diamond Shamrock	50	42	36	29	24	20	14	12	12	11	11
Dow Chemical	310[b]	269	232	203	188	167	149	118	105	95	92
Du Pont	480	415	377	367	353	336	344	286	265	259	270
Ethyl Corp.[c]	na	29	25	28	25	19	25	22	20	20	18
W. R. Grace	50	46	41	34	30	30	32	28	22	21	21
Hercules	53	47	40	37	35	30	30	25	24	22	22
Monsanto[d]	195	174	144	132	114	116	87	82	92	87	98
Olin[e]	na	26	25	25	25	24	19	18	16	8	8
Pennwalt[d]	na	24	23	21	19	16	14	13	18	17	18
Rohm & Haas	62	54	49	45	43	45	39	32	25	29	31
Stauffer Chemical	45	37	34	33	29	24	20	17	14	14	14
Union Carbide	174	161	156	156	142	120	94	77	70	78	78
TOTAL[f]	**$1790**	**$1579**	**$1402**	**$1304**	**$1188**	**$1093**	**$989**	**$828**	**$772**	**$758**	**$780**
ANNUAL CHANGE[f]	**13%**	**13%**	**8%**	**10%**	**9%**	**11%**	**19%**	**7%**	**2%**	**−3%**	**1%**

a Planned. b C&EN estimate. c R&D definition narrowed after 1974. d R&D definition narrowed after 1972. e For chemicals only before 1972. f For 14 companies only. na = not available.
Sources: Company data, C&EN estimates

Upjohn

POLYMER CHEMICALS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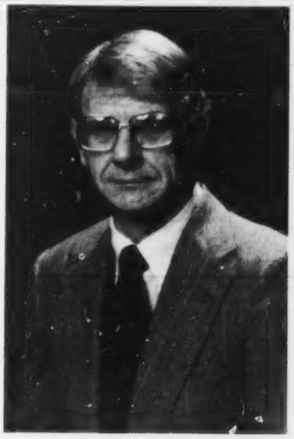
Polyurethane '80

The Americas

Eugene D. Eike
Director, North & South
American Business



Raw Materials and Energy

Times are changing. The polymeric isocyanate industry used to be a minor user of petrochemical raw materials. However, our supply requirements increased dramatically in the last decade and will continue to grow in the years to come.

Looking ahead, the polymeric MDI isocyanates industry will be dependent on OPEC, like much of the chemical industry. Although the chemical industry consumes only five to six percent of U.S. oil, international crises make it difficult to accurately predict the oil supply for the coming decade.

Most energy outlooks are based on declining oil and gas supplies through the '80s, as nuclear, synfuels and coal take up the slack. Synfuels from coal are predicted to emerge as a viable alternative in the mid-'80s.

Benzene—the most important polymeric MDI raw material—accounts for approximately 40 percent of isocyanate raw material costs. The price of benzene has risen dramatically, squeezing MDI profit margins.

After the 1973-74 shortage, benzene prices stabilized between 70 cents and 80 cents per gallon for three years. Then, due to OPEC price increases and tight supply, prices soared to $1.75 per gallon in 12 months and will probably exceed $2.00 per gallon this year, reaching $3.00 a gallon by 1983-84.

Only five to six percent of the total supply of benzene goes into polymeric isocyanate. The competing demand for gasoline and OPEC prices—not the isocyanate industry—primarily influence benzene prices. And demand for more unleaded gasoline will require more aromatics like benzene, even though total gasoline consumption is predicted to decline in the early '80s. Furthermore, demand for toluene as an octane booster—a function formerly performed by lead and manganese additives, now banned or greatly reduced by action of the federal government—diverts toluene from benzene production.

New gasoline additives, such as MTBE (methyl tertiary butyl ether) and TBA (tertiary butyl alcohol), will not be sufficiently available to offset banned lead and manganese additives. MTBE also reduces the supply of methanol, the major raw material used in making formaldehyde—another polymeric isocyanate raw material. Methanol demand will tighten supply and boost prices, particularly as there is little incentive to build the needed methanol capacity as supply of natural gas—the primary raw material source for methanol—is limited.

The other major raw materials, chlorine and caustic, are energy intensive. Thus, all the major raw materials are highly dependent on energy or fuel costs. With no relief in sight from the government or OPEC, the price of polymeric MDI isocyanate must follow the escalating costs of energy and fuel.

James Burt
Group Manager, North & South
American Sales

Versatility Spurs Growth

The past 10 years were a decade of remarkable growth for the entire polyurethane industry, setting the standard by which other plastics industries could judge their performance.

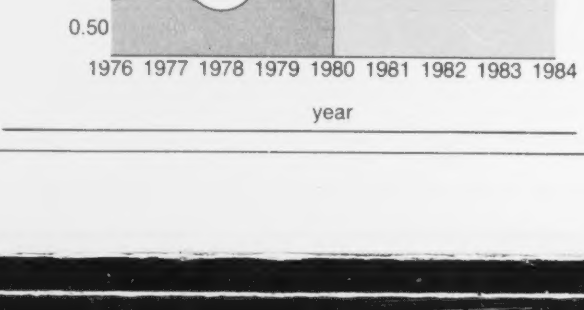
Energy conservation accelerated the use of polyurethane and isocyanurate foam insulation in new residential as well as commercial applications. An entirely new market area developed—namely the "retrofit" market—as insulating values were upgraded on existing structures using rigid foam insulation.

Ten years ago, RIM elastomer technology did not exist. Today it is one of the fastest growing, most exciting developments in the entire plastics industry. We can expect to see current producers of RIM parts expand in the '80s and introduce many forward-thinking new entries in the marketplace.

During the '70s, skateboards with cast or injection-molded polyurethane elastomer wheels were "in." By the end of the decade, declining skateboard sales were completely offset by the resurgence of roller skating. It's just one example demonstrating that if a product is versatile—and the polyurethanes certainly are—and the application has merit, a successful marketing venture often results.

We at Upjohn Polymer Chemicals view the '80s as a challenging opportunity . . . to develop new materials and to meet the ever-changing markets for these versatile products known as the polyurethanes.

Benzene Prices ($ per gallon)



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Dr. Peter J. Manno
Manager, Market Research & Commercial Development

Outlook for Polyurethane Markets

U.S. and Canadian demand for polyurethanes continues to escalate, particularly in the transportation and construction industries, fueled by energy conservation.

The next decade looks encouraging. Further energy conservation measures demand insulation with polyurethane. Exteriors of small, fuel-efficient automobiles will require liberal amounts of polyurethane elastomers. And new polyurethane applications will generate additional U.S. and Canadian demand that may well exceed five billion pounds (2.3 million tons).

United States

National demand for polyurethane increased approximately 12 percent a year during the last decade, as flexible foam cushioning expanded furniture and transportation markets, and demand for energy-saving polyurethane rigid foam insulation grew. Total U.S. demand will reach 2,580 million pounds in 1980, despite any business recession or strain on production capacity.

The '80s appear promising for polyurethane products; estimated overall demand may approach 4.9 billion pounds, as shown in Figure 1.

Flexible foam will continue to dominate polyurethane end uses. Its superior cushioning properties will maintain a nearly total penetration of furniture and transportation markets. Bedding applications may account for 30 percent of mattress units by 1990.

Rigid foam uses will average a nine percent annual increase and reach 1,620 million pounds by 1990—primarily due to growing demand for rigid foam insulation for building and construction.

Demand for polyurethane elastomers will double during the '80s and reach 550 million pounds. Transportation will account for 60 percent of the projected increase, as U.S. auto manufacturers comply with federal fuel economy standards. Other polyurethane elastomers will be chosen for high-performance applications requiring superior wear and resistance to corrosion and abrasion.

Coatings, adhesives and sealants are projected to grow a record 12 percent per year during the coming decade. Polyurethane coatings—high solids paints for autos in particular—and the emerging use of polyurethane binder adhesives in foundry cores and woodchip particleboard could well exceed the forecasted 720 million pounds for 1990.

Polyurethane products used in building and construction (including commercial refrigeration) will increase at a record pace during the '80s, from 390 million pounds to 1.1 billion pounds as shown in Figure 2. Demand for polyurethane foam residential sheathing will increase despite the current slowdown in residential housing starts. Demand will accelerate as housing starts return to normal levels.

Commercial roofing uses polyurethane rigid foam panels for the typical asphalt built-up roof construction. Polyurethane foam is ideal for asphalt-free, single-ply membrane roofing, using thicker layers (three inches or more) of insulation to maximize energy conservation. Residential sheathing may prove to be the fastest growing market, as consumers combat rising fuel and energy costs by using more efficient home insulation.

Fig. 1 Outlook of U.S. Polyurethane Demand.

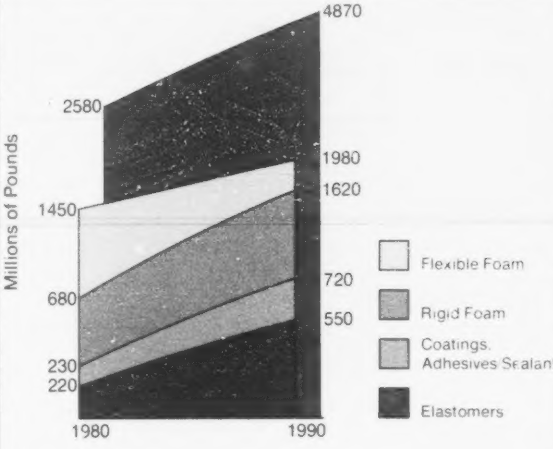
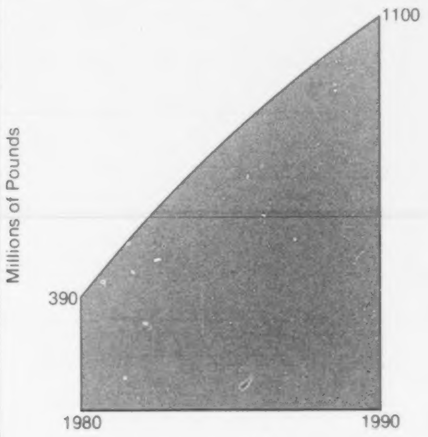


Fig. 2 Building/Construction Rigid Polyurethane Foam Demand.



Polyurethane rigid foam insulation may also be applied as a spray system on various surfaces. Retrofitting commercial roofs and insulating tanks and pipes have become popular. Emphasis on conserving energy in manufacturing facilities offers an ideal marketing opportunity for sprayed rigid foam insulation. By the end of this decade, demand for spray systems could double to 250 million pounds.

Transportation markets have always been major users of polyurethane products. Molded flexible foam cushioning provides superior seating and significantly reduces assembly labor costs. Although demand will fall as autos become smaller, it should recover to reach 430 million pounds in 1990 (Figure 3).

The auto industry, recognizing the need for improved fuel economy, has utilized lightweight polyurethane elastomers in flexible bumper fascia, trim and decorative body parts. Recently developed glass-filled polyurethane elastomers are being tested as possible auto fenders, doors and trunk lids.

The 90 million pounds projected for 1980 should nearly quadruple by the end of the decade. Widespread use of polyurethane elastomer external body components could add at least 100 million pounds to this total.

Of the many other end-use markets for polyurethane products, the three applications listed in Figure 4—footwear, carpet underlay and adhesive binders—appear most promising.

Polyurethane elastomer shoe soles are popular in women's fashion shoes and in sports footwear. Lightweight microcellular elastomer soles permit wide styling flexibility in women's shoes and can even simulate wood, cork, leather, and hand-stitching. Stylish sports shoes incorporate multi-color and multi-density soles. Current trends indicate this market could reach 75 million pounds by 1990.

Flexible polyurethane foam carpet underlay, using either prime or rebonded foam, offers superior cushioning and is particularly attractive for contract installations or premium carpets. The prime foam usage should reach 140 million pounds in 1980 and will probably increase at a rate of eight percent a year during this decade. Depending on scrap foam supply, demand for rebonded foam carpet underlay may approach 300 million pounds annually.

Polyurethane is well-recognized as a foundry adhesive or binder. As a binder for sand cores in metal casting, polyurethane is fast and energy-saving. Isocyanates are now used as binders for woodchip particleboard. Coated wood chips can be pressed into a particleboard or formed as a bonded woodchip core between thin wood veneers. Products containing isocyanate offer an excellent weather-resistant particleboard, as well as a manufacturing process that is formaldehyde-free and consumes less energy. These adhesive binder applications will total about 85 million pounds in 1980 and should increase rapidly to 350 million pounds over the next decade.

Canada

Canadian demand for polyurethane products parallels the U.S. growth pattern. Total demand in 1980 should reach 176 million pounds, slightly more than in 1979. Experiencing a decade of reasonable growth, in 1990, polyurethane demand could reach 350 million pounds.

End-use market potential also resembles U.S. trends. Transportation markets will use flexible foam cushioning and more polyurethane elastomers for bumper fascia and exterior auto body parts. Energy-saving insulation in extremely cold climates offers an excellent application for polyurethane rigid foam. And the well-established Canadian woodchip particleboard industry could become a significant user of isocyanate adhesive binder.

Fig. 3 Transportation Demand for Polyurethanes.

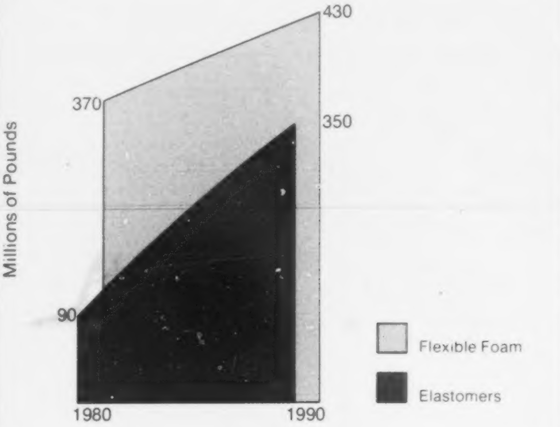
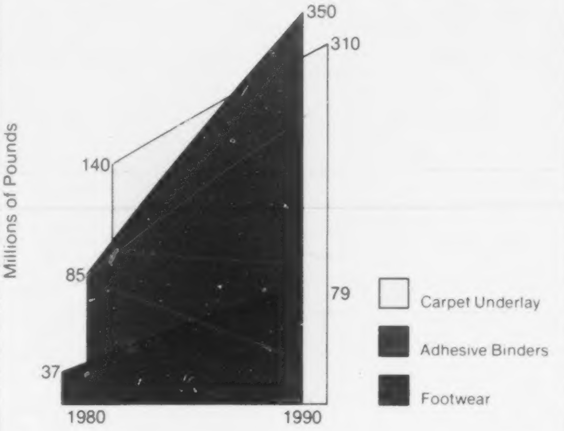
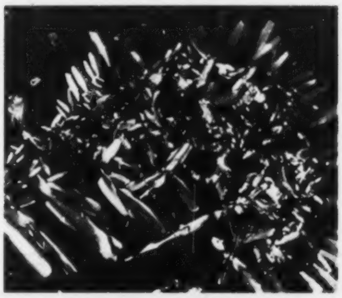
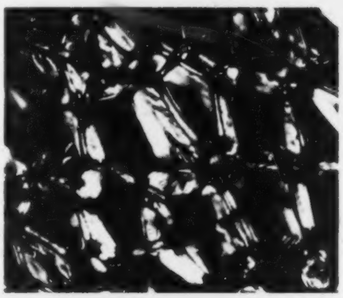


Fig. 4 Polyurethane Demand for Other Markets.

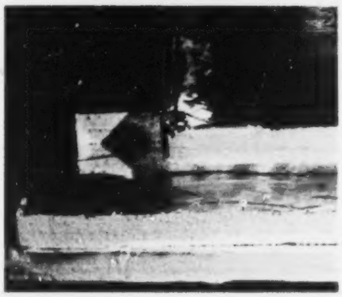




A crystal of pure MDI, the isocyanate cornerstone of the polyurethane industry, in a polarized light photomicrograph.

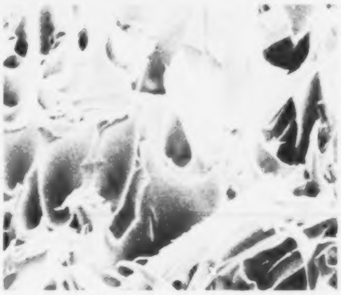


A crystal of polymeric MDI, the basis for the PAPI family of low-density polyurethane and isocyanurate foams as well as high density polyurethane foam for furniture and industrial parts, and for semiflexible foam used by the automotive industries.



Low-density polymeric foam affords insulation and physical properties for a variety of construction and transportation applications.

Woodchips and Upjohn's polymeric isocyanurate binder combine to make particleboard. The binder will not stick to particle board molds, allowing faster, more efficient production of the construction material.



Scanning electron micrograph of a cross-section of RRIM automotive material made from Upjohn Isonate® pure MDI reinforced with glass fiber.

D. D. Threlkeld
Director, Administrative Services

The Changed & Changing Environment

Energy conservation catalyzed polyurethane growth in the '70s and will continue to be the major impetus for growth in the next decade.

Back in 1970, energy seemed cheap and abundant, and much of the industry's development effort aimed towards esthetic and recreational applications. For example, we anticipated growth in decorative polyurethane wood replacements for Mediterranean-style furniture.

Polyurethane elastomers were used for snowmobile treads and integral-skinned skis, and for skateboard and rollerskate wheels. Introduced as a styling-oriented, conventional shoe sole material, polyurethane is now recognized for its superior wear and comfort.

Rigid polyurethane foam was well established as an insulant for commercial building by 1970, but residential use remained limited by building codes, resistance in the marketplace, and lack of modular building products.

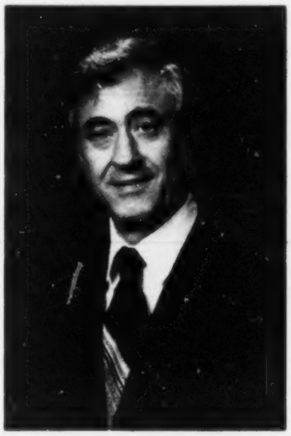
Regulatory constraints may actually boost polyurethane demand in the '80s. Federally mandated building insulation standards—for example, R-19 walls—would certainly increase the use of more rigid PUR foam chemicals. With polyurethane's superior insulating properties, stringent standards will tend to favor polyurethane over competing insulation materials. In the automotive area, federally mandated standards for fuel economy and impact damage will encourage the use of polyurethane elastomers.

Workplace safety is a vital concern of the chemical industry, but ineffectual government regulation merely adds to costs. It appears that the new Toxic Substances Control Act will jeopardize the development of many new chemicals, because of the prohibitive cost of premarket testing. This may deprive the polyurethane industry of new chemicals which could lead to new applications. Our legislators and bureaucrats continue to try to enforce a no-risk environment at great cost to industry and consumers alike.

Yet the public is recognizing that government controls and litigation inhibit growth and innovation and contribute to inflation. Small businesses are often hit hardest. R&D spending among chemical intermediate manufacturers continues to increase, but is limited by sales dollars allocated for energy costs, inflation, high interest rates, and the cost of regulatory compliance. Free enterprise and cost/benefit principles must prevail between government and business if these problems are to be solved by 1990.

Although the future has never been more uncertain, isocyanates and polyurethane products are expected to meet the challenge of change in the eighties as they did in the seventies.

Joseph A. Pagliuca
Assistant to the
Group Sales Manager



Polyurethane Insulation

Efficient insulation materials are of growing importance in both commercial and residential construction, boosting the use of plastic foam—particularly rigid polyurethane. Demand for continuous laminate panels has expanded rapidly during the past five years and will continue to grow.

Laminate producers are well aware of polyurethane foam's advantages as a sheathing and roof insulation material and are consistently developing new technology and better quality control to fully utilize the physical and chemical properties of rigid polyurethane foam.

A polyisocyanurate or polyurethane foam core is produced by continuously laminating foam to various facings, on a conveyor that controls the thickness of the panel. The foam cores are integrally bonded to facings including asphalt-saturated organic and inorganic felt, aluminum foil, and poly kraft paper.

Bonding the foam core to the facers creates a strong, tough insulation panel with excellent dimensional stability for better installation. In commercial and industrial roof insulation, boards are available with substrates of perlite, glass fiber, or gypsum board, and top facings of asphalt-saturated felt or glass-fiber mat. Composite boards act as thermal barriers; the upper faces serve as vapor barriers. And the advent of a noncomposite roof insulation board, combining glass fibers and an isocyanurate foam core within facings of asphalt-saturated asbestos, promises superior dimensional stability.

Insulation values are changing drastically, and demand for premium insulation will increase as utility costs rise. R-value standards are continually changing and vary from R-12 to R-20, depending on geographic location. Many states require an R-20 minimum in roof construction; builders are erecting homes using R-19 or better insulation on exterior walls. Although new construction in 1980 may be temporarily down, the retrofit market has tremendous potential, at least equalling new nonresidential construction on a square foot basis. Integral wall panels composed of polyurethane gypsum composites are making inroads—upgrading walls, in retrofit and in new construction. Now contractors are able to produce wall insulation and interior finish simultaneously. Using integral panels in new construction eliminates two steps and cuts installation time in half.

Foamed plastics comprise 21 percent of the market and are expected to reach nearly a 50 percent market share by 1985.

Roof systems have traditionally been waterproofed with the conventional technique widely referred to as

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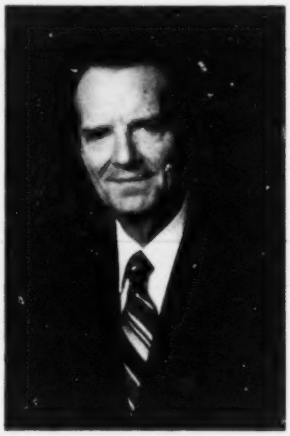
Charles E. McLouth
Sales Manager, North
American Sales



Competitive Plastic Materials, Also on the Move

The decade ahead promises to be an exciting period for the plastics industry. New compounds and technologies will replace the old familiar ones... new process innovations will give birth to new end products opening up new horizons for growth. Current developments represent only the tip of the iceberg. Some of these developments may result in more new substitutes for metals where polyurethane processes like RIM have made big inroads, and other materials will continue to gain in usage. Epoxy plastics, like polyurethane thermoplastics, will increase usage in automotive and nonautomotive applications. Phenolic insulation foams and new manufacturing processes for expanded polystyrene materials will provide new entries in laminate markets. The polyurethane industry must monitor these competitive materials and their future applications so that polyurethane can continue to pace the burgeoning plastics industry.

For instance, consider the recent process innovation that produces a hard skin on expanded styrene foam, opening up a new field for EPS in furniture, insulation foams, automotive applications, and advertising materials. New foil bonding techniques will make EPS insulation board easier to handle and more effective. Phenolic insulation (R-value of 4.5 to 5.5) foams, which are fabricated into board stock, promises a low burn rate and low smoke generation equivalent to isocyanurate foams. However, the foam and application techniques must be improved to eliminate the corrosive effects and to improve fragility. The use of high molecular-weight copolymer of polyethylene will increase rigidity and low-temperature crack resistance in this material, opening new vistas for automotive and structural foam applications.

New developments have emerged that vastly improve the properties of sheet molding compound and its processing. Thick molding compound (TMC) has made SMC stronger and more economical. New faster reacting versions of SMC will cut the thickening time and provide more toughness and impact-resistance. This will increase its usefulness in automotive applications such as structural members, door panels, front ends, and bumper assemblies along with polyurethane. Sheet molding urethane compound (SMUC) has better physical properties than SMC and reportedly is more economical than polyurethane RIM materials. New in-mold polyurethane coating processes may make a Class A finish on SMC possible. Class A finishes open up applications for auto body parts including fenders, door panels, front and rear ends.

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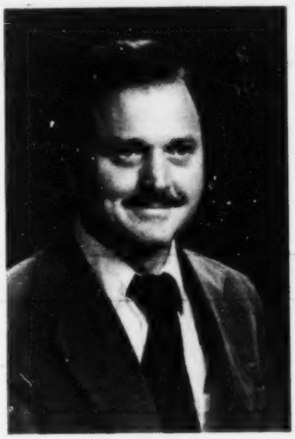
T. Roy McClellan
Manager, Customer Technical Services



Polyurethane Elastomers

As processes and chemical know-how continue to broaden the scope of polyurethane elastomer applications, it is evident that the potential for these unique and versatile rubbers and elastoplastics has barely been tapped. U.S. production is between 75 and 80 million pounds of high-performance elastomers. The industry anticipates a quantum jump in this decade.

Federal pressure for improved auto mileage will continue to mandate lighter vehicles. RIM-molded elastomers should continue to enjoy strong growth in "soft front ends," and the early eighties will see the first RRIM (reinforced RIM) structural exterior automotive fenders, trunks, and doors.

Polyurethane elastomer parts produced via thermoplastic processes since their inception in the early sixties have been gradually accepted by plastics fabricators. Today, the market consumes 30 million pounds of these polymers with growth commensurate with their role as "engineering" rubbers.

Polyurethane spandex fibers should continue their steady growth through the eighties. Fashion trends demanding lighter weight, leisure and sports apparel should increase the need for the highly elastic and supportive qualities of spandex fiber in these fabrics.

Cast microcellular polyurethane elastomers, like their solid counterparts, exhibited excellent abrasion resistance and moldability and emerged during the late sixties as an ideal fashion shoe material. This application began in Italy and spread throughout the world. Current PU soling production in the U.S. runs about 20-25 million pounds per year.

In the eighties, polyurethane microcellular elastomers are apt to follow a more even growth curve. Spin-off technology from the RIM automotive area should add impetus to growth in high-density, durable men's soles and sport boots.

The castable elastomer market, currently utilizing 30 to 40 million pounds per year, is based on more than two decades of steady progress. The recognized advantages of cast polyurethane rubbers, where liquids could be poured into low-cost tooling and converted *in situ* to tough, thermoset elastomers exhibiting extraordinary abrasion resistance in a diversified aqueous/oil/dry particulate or mechanical wearing applications, should greatly intensify growth during the next decade. Future utilization of the RIM process for these applications will enable higher production rates and further allow penetration of the traditional energy intensive rubber markets.

Victor V. D'Ancicco
Product Business Manager

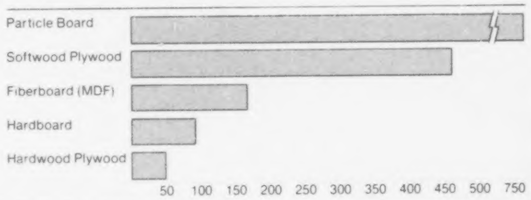
Isocyanate Binder Technology

Isocyanates have been used to manufacture adhesives and binders for years. Of the 1979 total polyurethane demand for adhesives and sealants (108 million pounds), 60 million pounds were consumed as a sand binder for foundry core production. Usage will drop in 1980, due to reduced automotive production and smaller castings—but demand in the '80s should increase approximately seven to eight percent per year. Rising energy costs will spur the growth of "no bake" sand binders produced with isocyanates.

The construction industry used only 10 million pounds of isocyanates and polyurethanes as binders/adhesives last year. Urea-formaldehyde (UF) and phenol-formaldehyde (PF) are traditionally used as binders and adhesives in the production of plywood, particleboard, hardboard, and medium-density fiberboard (MDF). It is estimated that in 1978 more than 19.7 billion square feet (¾" basis) of softwood plywood was produced, consuming over 450 million pounds of phenolformaldehyde. By 1985, the total plywood demand will be greater than 22 billion square feet.

Although adhesive consumption for plywood was at record levels for 1979, the trend will change as rising interest rates and tight mortgage money cause a downturn in the construction of single family dwellings, possibly into 1981.

1978 Binder/Adhesive Usage in the Wood Industry (MM lbs.)



And suitable logs for plywood production are becoming more expensive and scarce. According to The American Plywood Association, the price of forest timber has increased more than four times since 1970, while the cost of plywood has increased about 2.5 times—promoting the full utilization of the biomass via production of particleboard, composite board... and, more recently, flake board. In plywood production, approximately 45 percent of a log is converted to veneer, whereas particleboard or composite board production uses virtually all of the log; almost the entire tree, including limbs, bark, and roots, can be used.

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Polyurethane Insulation Continued

BUR (built-up roofing). Now alternative systems, such as the single-ply roof membrane, are seen as the future of the industry to offset rising asphalt prices and labor costs.

The single-ply roof membrane is one new, popular alternative. There are two types of single-ply systems: loose-laid membrane topped with ballast and smooth-roof membrane without ballast. The smooth-roof membrane is fastened to the deck surface with adhesive; the loose membrane system is chemically or thermally fused to the membrane surfaces being joined (not attached to the roof substrate).

With polyurethane's proven record as a thermally efficient insulation—plus new technology and improved application methods—the market for this important product will continue to thrive.

Competitive Plastics Continued

New filled (30 percent to 45 percent) thermoplastic polyesters are now available which eliminate previous warpage problems. Further refinements will qualify them for use in exterior automotive body components.

Constant innovation and achievement are necessary to survive in today's plastics industry. At Upjohn we believe that with new polyurethane compounds, improved processing technology, and new combinations of polyurethane sandwich materials, our polyurethane products will more than hold their own in the marketplace of the '80s.

Isocyanate Binder Technology Continued

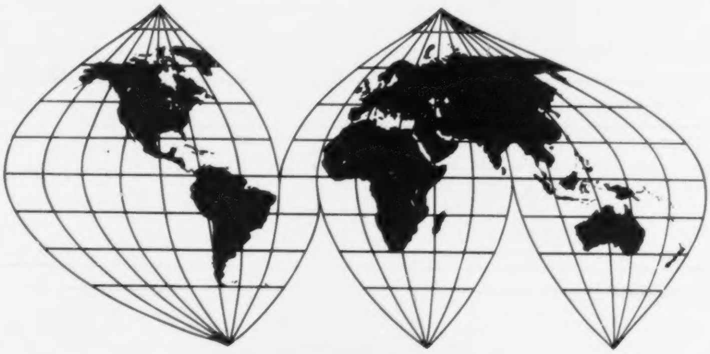
Most of the particleboard production in the U.S. has used urea-formaldehyde as the binder resin and was confined to interior use, with half of the production going for furniture, 20 to 25 percent for floor underlayment, 10 to 15 percent for mobile home construction and 5 to 10 percent for miscellaneous products.

The shortage of construction plywood in the early 1970s encouraged the use of structural particleboard and exterior binders. (Up to 1979, this type of board amounted to only about five percent of the particleboard produced, possibly due to the problems of using phenol-formaldehyde binder.)

In the 1980s, increasing wood shortages and costs will speed the development of structural particleboard, oriented strand board and composite products. The American Plywood Association has recently approved a new definition of "structural-use panel products." Qualified panels of composite construction, veneered or unveneered, used for certain applications will now be eligible for the full range of APA services.

Demand for wood products will explode in the '80s, as over 40 million Americans reach prime home-buying age of 30. Newer types of composite board, particleboard, wafer board, and oriented strand board will experience tremendous growth—perhaps exceeding 4.5 billion square feet per year.

To meet the growing need for faster-curing, more efficient binder resins, Upjohn recently introduced ISO-BIND™—enabling the total biomass, including hardwoods, to be used in an exterior environment with no release of formaldehyde fumes.



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Profitability has been improving for the chemical industry generally. But, as a glance at the figures on this and the following four pages indicates, there are wide variations within the industry. Much depends on what types of chemical products a company makes and what markets it serves in determining whether its profit margins and return on stockholders' equity will be above or below average.

By and large, companies that focus on specialty products tend to reap the largest profits relative to sales or net worth. Hence, no other major chemical producer earns more, per dollar of sales, than International Flavor & Fragrances, although Lubrizol and Nalco Chemical top it in return on equity (and also enjoy well-above-average margins themselves).

Even better positioned to turn a profit are some of the major pharmaceutical companies, especially ethical drug firms with widely used products that have strong patent protection. A prime example is SmithKline, with its hot-selling Tagamet drug for gastrointestinal disorders; sales of Tagamet and related products accounted for a third of SmithKline's total.

On the other end of the profitability spectrum are likely to be found companies making commodity-type products and selling into highly competitive, price-sensitive markets. Cases in point: fertilizer producers such as Williams, Terra Chemicals, and First Mississippi whose profits have been crimped during the past couple of years by price competition and soaring costs for feedstocks, especially natural gas.

Explanation of table headings

Year. Data are for calendar year unless otherwise indicated.

Net sales. Gross sales, less discounts, allowances, and returns; generally excludes excise taxes and other operating income or revenues.

Net income. Net sales and other income, less operating costs, nonoperating charges, depreciation, depletion, interest expense, deferred charges, minority interest in income, and taxes. Nonrecurring or extraordinary credits and charges have been excluded in most cases, but these items are indicated by a footnote.

Total assets. Sum at year's end of current assets, investments, prepaid expenses, net plant and equipment, and other tangible assets. Excludes insofar as possible intangible assets including goodwill, value of patents and trademarks, and the like.

Current ratio. The ratio of current assets (cash, marketable securities, receivables, and inventories but excluding prepaid expenses) to total current liabilities.

Net plant and equipment. Value at year's end of fixed assets, less accumulated depreciation, amortization, and depletion.

Capital expenditures. Total spending during the year for new fixed assets, such as plant, equipment, and land, and for replacement and modernization of facilities.

Net worth. Equity at year's end of preferred and common stock holders, including value of capital stock, capital and earned surplus, and surplus reserves, as well as contingency and miscellaneous reserves for which no definite purpose is stated. Intangible assets are deducted insofar as possible.

Net income (breakdown). **Per cent of sales:** net income divided by net sales. **Per cent of net worth:** net income divided by tangible net worth. **Dollars per share:** net income, less preferred dividends, divided by the number of shares of common stock outstanding. All figures are adjusted for stock splits but no adjustment has been made for earlier years as a result of stock dividends nor for dilution that might result from the conversion of preferred stock or debt to common stock or the exercise of stock options outstanding.

Dividends per share. Cash dividends paid (or declared) on each share of common stock; excludes the value of stock dividends, which are indicated by a footnote.

Dividend yield. Dividends per share divided by the average of the high and low prices of the common stock during the calendar year.

Stock price range. High-low market prices of common stock during the calendar year, adjusted for stock splits but not for stock dividends.

Price-earnings ratio. Average of the high and low prices of the common stock during the calendar year divided by net income per share of common stock.

Money figures in thousands of dollars unless otherwise indicated

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME			Dividends, $ per share	Dividend yield, % of price	Stock price range, $ per share	Price-earnings ratio
								% of sales	% of net worth	$ per share				
CHEMICALS														
Air Products & Chemicals														
1979[a]	$1,229,894	$97,540	$1,415,024	1.3	$945,013	$246,050	$563,702	7.9%	17.3%	$3.45	$0.65	2.1%	$37¼-23¾	8.8
1978[a]	1,039,052	76,184	1,180,754	1.2	801,809	199,847	477,557	7.3	16.0	2.70	0.50	1.8	31⅞-22½	10.1
1977[a]	947,239	67,707	1,022,540	1.5	691,904	142,616	416,190	7.1	16.3	2.40	0.25[b]	0.9	35⅞-21	11.8
1976[a]	818,213	63,479	891,881	1.4	934,253	160,433	353,396	7.8	18.0	2.30	0.125[b]	0.4	41½-29⅝	15.5
Akzona														
1979	$1,012,398	$25,647	$818,125	2.2	$402,178	$54,486	$323,875	2.5%	7.9%	$2.10	$0.80	5.6%	$17⅛-11¼	6.8
1978	868,711	20,832	704,095	2.5	374,065	42,404	307,790	2.4	6.8	1.69	0.80	6.0	15¼-11¼	7.8
1977	808,847	7,523	674,937	2.6	374,315	35,191	300,287	0.9	2.5	0.60	1.10	7.2	19⅛-11¼	25.3
1976	728,571	5,622	675,134	2.6	382,085	38,126	306,594	0.8	1.8	0.45	1.20	6.1	25¾-13⅜	43.5
Allied Chemical Corp.														
1979	$4,332,391	$201,080[c]	$4,159,798	1.1	$2,168,816	$408,668	$1,377,701	4.6%	14.6%	$6.84[c]	$2.00	5.1%	$49½-28½	5.7
1978	3,267,956	124,557[d]	3,182,335	1.4	2,041,409	502,040	1,226,710	3.8	10.2	4.40	2.00	5.5	44¾-27⅝	8.2
1977	2,922,751	138,378[e]	2,825,965	1.7	1,809,369	464,638	1,151,112	4.7	12.0	4.93[e]	1.85	4.1	51⅜-38¾	9.1
1976	2,629,567	126,305[f]	2,382,823	2.0	1,454,105	346,776	1,057,784	4.8	11.9	4.52[f]	1.80	4.6	44⅞-33⅜	8.7
American Cyanamid Co.														
1979	$3,186,998	$168,495	$2,810,725	1.6	$1,303,308	$235,416	$1,331,130	5.3%	12.7%	$3.52	$1.60	5.3%	$36⅛-23¾	8.5
1978	2,780,170	155,943	2,510,038	1.8	1,212,807	251,034	1,238,396	5.6	12.6	3.26	1.50	5.4	32⅞-22⅝	8.5
1977	2,412,311	139,400	2,205,363	2.0	1,081,908	235,451	1,152,003	5.8	12.1	2.92	1.50	5.7	29¾-23	9.0
1976	2,093,815	135,766	1,985,125	2.3	916,708	231,844	1,091,871	6.5	12.4	2.84	1.50	5.8	28⅛-23½	9.1

a Fiscal year ends Sept. 30. b Plus 2% stock dividend. c From continuing operations; excludes net losses from discontinued businesses of $164.8 million ($5.75 per share) and nonrecurring net losses of $25.4 million ($0.89 per share). d Excludes nonrecurring net loss from sales of plants of $4.3 million ($0.15 per share). e Excludes extraordinary charge representing costs related to Kepone problem of $3.1 million ($0.11 per share), but includes net gains on disposition of operating assets and real estate, less provision for write-off of notes held or guaranteed, of $16.0 million. f Excludes extraordinary net charge representing costs related to Kepone problem of $9.5 million ($0.34 per share), but includes gains on disposition of operating assets and real estate, less loss on termination of gas supply contract, of $18 million.

Money figures in thousands of dollars unless otherwise indicated

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME			Dividends, $ per share	Dividend yield, % of price	Stock price range, $ per share	Price-earnings ratio
								% of sales	% of net worth	$ per share				
Big Three Industries														
1979	$509,449	$62,859	$700,052	2.3	$488,921	$ 79,710	$404,137	12.3%	15.6%	$3.13	$0.84	2.2%	$44½-31⅝	12.2
1978	428,934	56,718	604,437	2.2	449,707	93,374	357,478	13.2	15.9	2.83	0.68	2.0	40½-29	12.3
1977	341,171	49,227	515,830	2.3	391,086	124,494	313,845	14.4	15.7	2.46	0.40[a]	1.3	35½-27¾	12.8
1976	274,508	36,612	439,591	3.0	288,154	107,056	268,385	13.3	13.6	1.91	0.33	1.0	40½-27⅞	17.9
Cabot Corp.														
1979[b]	$1,122,391	$70,445	$918,431	2.0	$401,638	$ 96,442	$358,031	6.3%	19.7%	$6.83	$1.40	3.5%	$50 -30½	5.9
1978[b]	713,136	46,580	752,089	2.5	353,020	111,902	303,542	6.5	15.3	4.59	1.05	3.5	38½-21⅛	6.5
1977[b]	574,836	39,901	575,322	2.6	273,104	50,258	280,932	6.9	14.2	3.79	0.75	3.5	24⅝-18½	5.7
1976[b]	460,997	29,373	515,462	2.6	259,707	44,270	263,731	6.4	11.1	2.75	0.50	3.2	21⅜-9⅝	5.6
Celanese Corp.														
1979	$3,146,000	$141,000	$2,374,000	1.8	$1,150,000	$245,000	$1,033,000	4.5%	13.6%	$9.52	$3.10	7.0%	$48¾-39⅜	4.6
1978	2,609,000	112,000[c]	2,148,000	2.0	1,148,000	248,000	936,000	4.3	12.0	7.61[c]	2.85	6.9	47⅛-35⅝	5.4
1977	2,320,000	70,000	1,998,000	2.0	1,119,000	243,000	816,000	3.0	8.6	4.70	2.80	6.0	53 -40	9.9
1976	2,123,000	69,000	1,897,000	1.8	1,071,000	223,000	783,000	3.3	8.8	4.67	2.80	5.6	58 -41¾	10.7
Crompton & Knowles Corp.														
1979	$239,638	$7,075	$131,433	2.2	$28,822	$7,895	$55,212	3.0%	12.8%	$3.05	$1.04	6.6%	$18⅜-13	5.1
1978	217,412	6,137	127,177	2.3	25,110	4,484	49,699	2.8	12.3	2.65	0.96	6.1	19 -12⅝	6.0
1977	192,729	5,408	107,175	2.7	24,105	2,976	45,938	2.8	11.8	2.35	0.90	6.0	17¼-12¾	6.4
1976	154,377	4,709	93,908	2.8	17,211	2,042	46,077	3.1	10.2	2.03	0.80	6.1	15¾-10½	6.5
Diamond Shamrock Corp.														
1979	$2,393,935	$178,123	$2,329,892	1.9	$1,382,931	$256,564	$931,267	7.6%	19.1%	$3.37	$1.51	6.0%	$31½-19	7.5
1978	1,677,602	131,063	1,959,509	1.9	1,294,970	286,843	790,555	7.8	16.6	3.26	1.42	5.8	29¾-19	7.5
1977	1,530,382	162,123	1,718,768	2.0	1,140,765	367,512	701,179	10.6	23.1	4.28	1.175	3.6	38⅝-26⅜	7.6
1976	1,356,552	140,030	1,389,506	1.9	912,071	285,457	580,146	10.3	24.1	3.90	0.95	2.9	40 -26½	8.5
Dow Chemical Co.														
1979	$9,255,387	$783,898[d]	$10,144,745	1.4	$5,236,404	$1,267,719	$3,789,746	8.5%	20.7%	$4.33[d]	$1.45	4.9%	$34⅞-24⅜	6.8
1978	6,887,623	575,224	8,705,081	1.6	4,762,129	1,075,173	3,310,655	8.4	17.4	3.16	1.25	4.7	30⅞-22	8.4
1977	6,234,255	555,703	7,591,752	1.5	4,199,539	1,163,016	3,033,636	8.9	18.3	3.01	1.10	3.2	43¾-25¼	11.5
1976	5,652,070	612,767	6,765,075	1.4	3,553,920	1,186,193	2,781,421	10.8	22.0	3.30	0.90	1.9	57¼-38⅜	14.5
E. I. du Pont de Nemours & Co.														
1979	$12,571,800	$938,900	$8,918,700	2.5	$3,942,400	$864,000	$5,290,600	7.5%	17.7%	$6.42	$2.75	6.5%	$48¼-37	6.6
1978	10,584,200	787,000	8,047,700	2.3	3,839,000	714,200	4,737,800	7.4	16.6	5.39	2.42	6.1	46⅛-32½	7.3
1977	9,434,800	545,100	7,379,500	2.5	3,886,200	703,600	4,265,900	5.8	12.5	3.69	1.92	4.8	45 -35⅛	10.9
1976	8,361,000	459,300	6,965,800	2.4	3,844,700	876,200	3,977,900	5.5	11.5	3.10	1.75	3.8	53¾-39⅛	15.0
Ethyl Corp.														
1979	$1,656,977	$97,515	$1,070,968	2.8	$512,981	$122,878	$536,671	5.9%	18.2%	$4.94	$1.35	5.3%	$30 -21	5.2
1978	1,422,451	82,698	1,001,584	2.9	446,346	95,803	514,693	5.8	16.1	4.24	1.10	5.1	24⅞-18½	5.1
1977	1,282,087	78,024	911,072	3.5	402,335	87,649	463,070	6.1	16.8	4.29	0.875	4.2	22⅞-18⅜	4.8
1976	1,154,210	69,080[e]	857,217	3.4	365,166	87,656	411,161	6.0	16.8	3.59[e]	0.75	3.8	24⅝-14¾	5.5
Ferro Corp.														
1979	$591,930	$30,912	$387,703	1.8	$115,831	$33,132	$200,625	5.2%	15.4%	$4.07	$1.14	4.7%	$29⅜-19	5.9
1978	494,414	27,657	310,612	2.0	86,805	19,385	175,618	5.6	15.7	3.67	1.05	4.0	35 -17⅛	7.1
1977	420,042	20,903	254,254	2.4	71,902	19,693	157,975	5.0	13.2	2.78	0.90	4.5	22⅝-17⅜	7.2
1976	376,485	20,054	246,301	2.1	68,150	10,442	143,960	5.3	13.9	2.68	0.76	3.9	24 -14½	7.2
First Mississippi Corp.														
1979[f]	$178,400	$ 4,661	$200,370	2.8	$63,942	$17,046	$95,073	2.6%	4.9%	$0.55	$0.40	2.0%	$29⅜-10	35.8
1978[f]	155,525	4,170	205,837	2.9	72,190	12,558	93,528	2.7	4.5	0.49	0.39	3.2	16½-8	25.0
1977[f]	161,448	14,435[g]	210,679	2.8	76,476	25,112	91,986	8.9	15.7	1.72[g]	0.36	2.8	17 -8⅝	7.4
1976[f]	148,174	12,909	169,164	2.6	64,243	25,887	79,819	8.7	16.2	1.52	0.36	3.0	15⅛-8½	7.8
W. R. Grace & Co.														
1979	$5,266,629	$222,580[h]	$3,680,847	1.6	$1,629,361	$477,688	$1,524,276	4.2%	14.6%	$5.02[h]	$1.975	5.9%	$41¼-25⅝	6.7
1978	4,309,588	170,403[i]	3,201,126	1.9	1,317,159	275,308	1,333,772	4.0	12.8	4.23[i]	1.85	6.6	32⅜-23¾	6.6
1977	3,976,233	140,475[j]	2,870,719	1.8	1,216,950	263,633	1,156,899	3.5	12.1	3.71[j]	1.775	6.2	31⅝-25⅞	7.7
1976	3,615,153	131,882[k]	2,681,401	1.9	1,050,335	212,096	1,080,881	3.6	12.2	3.55[k]	1.70	5.8	33⅞-24¼	8.2
Hercules														
1979	$2,345,425	$144,500[l]	$1,761,177	1.9	$772,889	$185,998	$945,422	6.2%	15.3%	$3.27[l]	$1.075	5.5%	$22¾-16⅛	5.9
1978	1,946,477	103,264[m]	1,590,306	1.9	714,286	115,807	812,159	5.3	12.7	2.36[m]	1.00	6.5	18⅝-12¼	6.5
1977	1,697,787	57,930[n]	1,469,276	2.2	721,292	127,484	749,303	3.4	7.7	1.36[n]	1.00	4.6	28½-14¾	15.9
1976	1,595,956	76,900[o]	1,423,124	2.2	699,383	150,294	734,862	4.8	10.5	1.78[o]	0.85	2.7	38 -24	17.4

[a] Plus 2% stock dividend. [b] Fiscal year ends Sept. 30. [c] Excludes cumulative effects of change in accounting for investment tax credits of $43 million ($3.01 per share). [d] Includes gain on sale of oil and gas properties, before taxes, of $84.8 million. [e] Includes loss on disposal of Oxford Paper division of $1.5 million. [f] Fiscal year ends June 30. [g] Includes gains on sale of oil and gas leases, from cancellation of raw material purchase contract, and on settlement of litigation of $5.1 million. [h] Includes net gains on disposal of businesses of $12.8 million. [i] Includes net gains on disposal of businesses of $8.0 million. [j] Includes net losses on disposal of businesses of $17.2 million. [k] Includes net gains on disposal of businesses of $810,000. [l] Excludes net gain on sale of pigments and methanol assets of $28.0 million ($0.62 per share). [m] Includes net loss from write-down of facilities of $4.9 million ($0.11 per share). [n] Includes net loss from write-down of facilities of $6.2 million ($0.26 per share). [o] Excludes nonrecurring net gain on sale of property, plant, and equipment of $29.9 million ($0.66 per share).

Money figures in thousands of dollars unless otherwise indicated

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME			Dividends, $ per share	Dividend yield, % of price	Stock price range, $ per share	Price-earnings ratio
								% of sales	% of net worth	$ per share				
International Flavors & Fragrances														
1979	$409,299	$61,472	$387,807	3.6	$114,255	$15,180	$285,425	15.0%	21.5%	$1.68	$0.74	3.4%	$25⅝-18¼	13.1
1978	365,881	56,199	345,073	3.4	109,092	20,014	252,706	15.4	22.2	1.53	0.59	2.5	27⅝-19⅝	15.4
1977	314,307	45,705	306,045	3.2	98,567	16,640	219,230	14.5	20.8	1.25	0.46	2.2	23⅝-18¼	16.8
1976	274,210	37,609	277,312	2.7	89,953	10,635	191,484	13.7	19.6	1.03	0.33	1.4	28⅜-19	23.0
International Minerals & Chemical Corp.														
1979	$1,474,700	$120,800	$1,537,600	1.7	$936,600	$173,500	$790,200	8.2%	15.3%	$6.72	$2.80	5.8%	$61½-35¼	7.2
1978[a]	1,364,400	120,100	1,461,900	1.9	879,400	193,600	721,000	8.8	16.7	6.61	2.60	6.7	43½-34	5.9
1977[a]	1,280,200	108,200	1,368,600	2.0	778,600	174,800	649,300	8.5	16.7	6.09	2.45	6.2	44⅛-35¼	6.5
1976[a]	1,260,000	135,400	1,248,900	2.1	666,000	154,900	580,700	10.7	23.3	7.75	2.10	5.6	42¼-32⅜	4.8
Liquid Air Corp. of North America														
1979	$369,109	$24,698	$399,354	1.7	$259,006	$50,714	$191,641	6.7%	12.9%	$2.49	$1.40	5.3%	$28¾-23¾	10.5
1978	304,266	18,346	299,419	1.8	180,327	37,092	121,097	6.0	15.1	2.48	1.40	5.2	30½-23½	10.9
1977	284,495	19,896	275,004	1.8	160,321	31,914	113,751	7.0	17.5	2.75	1.40	5.0	32¾-23½	10.2
1976	265,561	21,343	243,251	1.7	142,595	21,664	110,208	8.0	19.4	2.75	1.25	4.2	35 -24	10.7
Lubrizol Corp.														
1979	$724,734	$90,775	$519,942	2.5	$180,405	$50,807	$374,751	12.5%	24.2%	$4.66	$1.60	3.2%	$59⅞-41	10.8
1978	586,477	77,365	441,735	2.8	150,018	44,373	323,036	13.2	23.9	3.95	1.405	3.4	48¼-33⅜	10.3
1977	507,121	58,069	360,467	3.2	121,369	22,982	271,783	11.5	21.4	2.96	1.25	3.8	37⅝-27¾	11.0
1976	450,854	50,957	344,005	3.4	113,455	19,420	261,633	11.3	19.5	2.52	1.05	2.8	44⅞-31⅛	15.1
Mallinckrodt Inc.														
1979	$392,470	$31,932[b]	$317,798	3.4	$130,416	$19,640	$213,617	8.1%	14.9%	$3.40[b]	$1.05	3.5%	$33¼-26½	8.8
1978	365,722	28,841	271,030	3.8	125,585	17,062	180,778	7.9	16.0	3.07	0.90	2.7	41¾-26	11.0
1977	313,204	27,163	243,051	4.1	113,015	25,195	158,387	8.7	17.1	2.89	0.75	2.1	40¼-29¾	12.1
1976	277,687	24,183	212,424	3.8	93,856	26,675	137,630	8.7	17.6	2.62	0.55	1.3	49¾-36½	16.5
Monsanto Co.														
1979	$6,192,600	$331,000[c]	$5,539,100	2.2	$2,817,800	$565,900	$2,781,800	5.3%	11.9%	$9.11[c]	$3.35	6.3%	$ 62 -45	5.9
1978	5,018,700	302,600[d]	5,035,700	2.5	2,604,800	479,900	2,579,400	6.0	11.7	8.29[d]	3.175	6.1	60¼-44⅛	6.3
1977	4,594,500	275,600	4,350,100	2.6	2,408,700	607,100	2,400,900	5.9	11.5	7.46	3.025	4.3	88⅞-52	9.4
1976	4,270,200	366,300	3,959,100	2.9	2,089,800	646,800	2,252,500	8.6	16.3	10.05	2.75	3.1	100 -76	8.8
Nalco Chemical Co.														
1979	$578,908	$63,277	$368,074	2.5	$126,774	$39,018	$261,966	10.9%	24.2%	$3.18	$1.36	4.4%	$35⅝-26¼	9.7
1978	476,208	53,652[e]	309,666	2.5	105,197	34,278	221,814	11.3	24.2	2.71[e]	1.24	4.3	32¾-24⅜	10.5
1977	445,602	50,113	285,005	2.5	99,890	35,324	208,286	11.2	24.1	2.51	1.065	3.6	34⅝-24¾	11.8
1976	385,581	43,564	258,431	2.5	81,849	16,302	183,251	11.3	23.8	2.17	0.82	2.5	36½-29½	15.9
Olin Corp.														
1979	$1,778,102	$71,150	$1,461,073	1.7	$764,108	$161,151	$739,992	4.0%	9.6%	$2.97	$0.97	4.7%	$25 -16⅛	6.9
1978	1,560,075	62,769	1,393,064	1.7	742,158	162,519	691,563	4.0	9.1	2.62	0.88	4.5	25¾-13⅜	7.5
1977	1,472,500	78,116	1,276,097	2.0	666,580	208,140	553,066	5.3	12.0	3.24	0.815	4.2	22⅛-16⅝	6.0
1976	1,376,523	72,563	1,067,595	2.0	525,781	165,691	594,387	5.3	12.2	3.03	0.68	3.6	22½-15⅛	6.2
Pennwalt Corp.														
1979	$1,079,303	$49,997	$775,355	2.1	$298,420	$67,486	$346,140	4.6%	14.4%	$5.01	$2.20	6.1%	$35⅞-30½	6.6
1978	921,369	44,973	672,343	2.1	270,374	61,938	317,073	4.9	14.2	4.54	2.00	5.4	42½-31½	8.1
1977	834,895	41,733	608,654	2.5	241,432	45,957	288,782	5.0	14.5	4.23	1.75	4.9	39¼-31⅝	8.4
1976	777,315	34,910	554,741	3.0	200,349	38,989	265,913	4.5	13.1	3.56	1.54	4.8	37⅞-26¾	9.1
Reichhold Chemicals														
1979	$874,854	$12,230	$425,478	2.0	$179,960	$ 26,114	$194,619	1.4%	6.3%	$1.34	$0.74	5.4%	$16 -11¼	10.2
1978	753,885	12,038[f]	393,433	2.0	24,287	190,493	190,493	1.6	6.3	1.32[f]	0.74	5.4	16½-11	10.4
1977	673,942	13,711	383,055	2.0	173,136	26,222	186,499	2.0	7.4	1.70	0.74	4.5	20 -13¼	9.8
1976	585,129	16,085	324,024	2.0	158,499	21,757	144,398	2.7	11.1	2.33	0.70	4.4	19⅞-11⅝	6.8
Rohm & Haas Co.														
1979	$1,590,484	$95,495[g]	$1,191,903	2.3	$487,841	$ 68,328	$637,398	6.0%	15.0%	$7.39[g]	$1.76	4.4%	$48½-31½	5.4
1978	1,253,543	57,798[h]	1,074,656	2.3	464,335	66,431	557,511	4.6	10.4	4.49[h]	1.40	4.1	40¼-28⅛	13.1
1977	1,123,865	41,129[i]	1,019,736	2.5	483,248	78,915	520,236	3.7	7.9	3.20[i]	1.28	3.2	51½-28	11.2
1976	1,053,098	47,023[j]	1,085,227	2.0	493,310	110,840	501,223	4.5	9.4	3.66[j]	1.28	2.1	76¾-44½	16.6
Stauffer Chemical Co.														
1979	$1,526,160	$135,961	$1,846,866	1.7	$1,040,542	$239,303	$821,777	8.9%	16.5%	$3.10	$1.075	5.0%	$25 -17¾	6.9
1978	1,328,114	126,015	1,635,956	2.0	903,246	201,196	730,064	9.5	17.3	2.88	0.975	4.7	24⅝-17	7.2
1977	1,232,760	116,000[k]	1,412,754	2.7	782,060	193,436	659,839	9.4	17.6	2.66[k]	0.855	4.2	25 -15½	10.4
1976	1,100,000	113,016	1,251,480	3.1	662,832	198,775	580,022	10.3	19.5	2.60	0.68	2.8	27 -20¾	9.2

a Fiscal year ends June 30. b From continuing operations; excludes net income from ethical drug business of $554,000 ($0.06 per share) and net gain on sale of ethical drug business of $8.6 million ($0.91 per share). c Includes nonrecurring net charges for shutdown of European businesses of $53.2 million ($1.47 per share). d Includes net gain from divestiture of various businesses of $8.7 million. e From continuing operations; excludes net loss from discontinued Scientific Services operations of $14.5 million ($0.73 per share). f Includes loss on abandonment of phenol facility of $4.4 million ($0.38 per share). g Excludes extraordinary tax credit of $7.3 million ($0.57 per share). h From continuing operations; excludes provision for loss on disposal of discontinued operations of $2.5 million ($0.19 per share). i From continuing operations; excludes losses from operations and provision for loss on disposal of discontinued operations of $2.4 million ($0.18 per share). j From continuing operations; excludes losses from operations and provision for loss on disposal of discontinued fiber operations of $58.8 million ($1.12 per share). k Includes net gain on sale of Pasadena, Tex., fertilizer plant of $3.4 million.

Money figures in thousands of dollars unless otherwise indicated

								NET INCOME						
Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	% of sales	% of net worth	$ per share	Dividends, $ per share	Dividend yield, % of price	Stock price range, $ per share	Price-earnings ratio
Stepan Chemical Co.														
1979	$144,981	$4,794[a]	$112,700	2.3	$66,121	$13,575	$46,399	3.3%	10.3%	$2.56[a]	$0.83	4.2%	$23½–16⅜	7.8
1978	122,947	4,613	97,191	2.5	58,367	13,738	42,530	3.8	10.8	2.46	0.74	3.4	26⅞–16⅝	8.8
1977	108,951	5,625	81,743	2.0	49,322	16,181	39,195	5.2	14.4	3.00	0.63	3.1	24⅝–15⅝	6.7
1976	97,781	5,092	66,212	2.6	36,437	7,811	34,443	5.2	14.8	2.72	0.54	3.4	19¾–12	5.8
Terra Chemicals International														
1979	$254,109	$ 2,739	$137,775	2.6	$35,393	$2,670	$63,183	1.1%	4.3%	$0.29	$0.10	1.3%	$10⅛–5⅛	26.3
1978	198,901	1,277	134,292	2.3	37,674	9,339	62,132	0.6	2.1	0.01	0.70	9.0	10⅞–4⅝	—
1977	109,540	7,971	121,153	2.5	32,738	9,094	65,843	7.3	12.1	1.27	0.80	7.1	13⅜–9¼	8.9
1976	103,346	11,994	90,454	4.7	27,852	4,466	63,238	11.6	19.0	2.03	0.75	6.7	13½–9	5.5
Union Carbide Corp.														
1979	$9,176,500	$556,200[b]	$8,710,000	2.1	$4,458,300	$831,300	$3,949,900	6.1%	14.1%	$8.47[b]	$2.90	7.4%	$44½–34	4.6
1978	7,869,700	394,300[c]	7,776,000	2.0	4,118,900	687,800	3,548,300	5.0	11.1	6.09[c]	2.80	7.3	43¼–33⅝	6.3
1977	7,036,100	385,100[d]	7,328,600	2.1	3,840,800	805,400	3,312,400	5.5	11.6	6.05[d]	2.80	5.5	62⅜–40	8.5
1976	6,345,700	441,200[e]	6,606,400	2.3	3,375,500	964,500	3,039,900	7.0	14.5	7.15[e]	2.50	3.8	76¾–55⅝	9.3
Virginia Chemicals														
1979	$131,273	$4,240	$97,707	1.6	$54,341	$14,128	$31,356	3.2%	13.5%	$1.66	$0.64	4.7%	$16⅞–10⅜	8.2
1978	110,358	4,010	75,127	1.5	45,770	13,042	28,226	3.6	14.2	1.62	0.54	4.6	13⅜–10	7.2
1977	104,324	2,861	65,611	1.7	37,474	8,905	24,968	2.7	11.5	1.17	0.48	3.7	16–9⅝	11.0
1976	99,128	3,970	57,033	2.2	30,095	3,522	23,095	4.0	17.2	1.69	0.45	4.0	15–7⅜	6.6
Williams Cos.														
1979	$1,850,013	$69,450	$2,005,511	1.7	$1,190,526	$112,995	$737,949	3.8%	9.4%	$2.55	$1.00	4.2%	$32¼–15	9.3
1978	1,497,008	29,534[f]	2,075,114	1.6	1,223,884	131,940	705,567	2.0	4.2	1.09[f]	1.00	5.3	23⅝–14	17.3
1977	1,239,588	65,311	1,852,044	1.9	1,153,410	164,006	685,888	5.3	9.5	2.61	1.00	4.6	25⅞–18	8.4
1976	1,002,590	61,196	1,677,691	2.0	1,508,854	199,638	645,560	6.17	9.5	2.44	1.00	4.1	29–20	10.0
Witco Chemical Corp.														
1979	$966,758	$42,782	$551,891	1.9	$192,902	$40,890	$222,686	4.4%	19.2%	$4.83	$1.30	5.1%	$30½–20	5.2
1978	751,733	33,495	405,042	1.9	166,475	31,991	189,844	4.5	17.6	3.86	1.11	5.3	24⅞–16⅜	5.4
1977	632,412	24,643	340,654	2.5	135,180	29,404	167,384	3.9	14.7	2.87	0.97	5.1	22⅝–15⅝	6.6
1976	565,958	23,062	313,224	2.3	137,073	27,398	147,061	4.1	15.7	2.74	0.87	5.1	20–13⅝	6.2
PHARMACEUTICALS														
Abbott Laboratories														
1979	$1,683,168	$178,981[g]	$1,729,296	1.3	$466,970	$109,636	$896,028	10.6%	20.0%	$2.97[g]	$1.00	2.7%	$43⅜–29½	12.3
1978	1,445,017	148,626[h]	1,453,233	1.4	403,452	84,149	773,505	10.3	19.2	2.48[h]	0.78	2.4	40–25	13.1
1977	1,244,976	117,838	1,243,458	1.6	365,504	63,935	663,694	9.5	17.8	1.98	0.575	2.4	28⅝–19½	12.1
1976	1,084,856	92,467	1,076,183	2.0	325,238	53,355	574,903	8.5	16.1	1.63	0.455	2.0	27⅝–18⅞	14.2
American Home Products Corp.														
1979	$3,401,301	$396,039	$2,007,977	3.0	$408,899	$87,809	$1,239,315	11.6%	32.0%	$2.51	$1.50	5.6%	$29½–24⅜	10.7
1978	3,062,633	348,422	1,779,023	2.9	369,214	67,631	1,094,798	11.4	31.8	2.21	1.325	4.5	32¾–26⅛	13.3
1977	2,685,127	306,167	1,526,072	3.0	345,336	59,628	953,036	11.4	31.1	1.94	1.15	4.0	32⅛–24⅞	14.7
1976	2,471,727	277,931	1,425,705	3.2	324,011	52,706	906,335	11.2	30.7	1.75	1.00	3.0	37¾–28½	18.9
Baxter Travenol Laboratories														
1979	$1,191,193	$111,908[i]	$1,290,928	2.3	$500,976	$103,654	$723,510	9.4%	15.5%	$3.29[i]	$0.50	1.2%	$49½–35⅜	12.9
1978	1,004,196	91,683[i]	1,129,637	2.2	445,223	90,057	612,231	9.1	15.0	2.73[i]	0.40	1.0	49¾–32⅝	15.1
1977	844,446	75,120[j]	964,189	2.5	383,754	83,776	518,968	8.9	14.5	2.27[j]	0.285	0.8	40⅞–28¼	15.7
1976	681,364	60,395	837,247	2.7	337,060	71,474	440,479	8.9	13.7	1.85	0.22	0.5	46⅜–33	21.5
Bristol-Myers Co.														
1979	$2,752,777	$231,545	$1,837,648	2.4	$407,528	$95,022	$1,117,002	8.4%	20.7%	$3.50	$1.385	4.0%	$38¼–31	9.9
1978	2,450,429	203,048	1,619,015	2.3	358,515	81,922	981,624	8.3	20.7	3.08	1.19	3.5	40⅜–28	11.1
1977	2,191,433	174,261	1,422,181	2.3	313,846	70,439	839,279	8.0	20.8	2.72	1.05	3.2	35⅞–28¾	11.9
1976	1,986,370	156,806	1,257,633	2.3	264,662	44,856	733,194	7.9	21.4	2.45	0.90	2.5	41⅞–30⅝	14.8
Eli Lilly & Co.														
1979	$2,205,764	$329,531	$2,179,132	2.4	$672,610	$172,678	$1,570,439	14.9%	21.0%	$4.52	$1.95	3.5%	$63⅞–47⅛	12.3
1978	1,852,090	277,475	2,049,901	2.1	551,657	89,550	1,384,082	15.0	20.0	3.81	1.65	3.6	54–36⅝	11.9
1977	1,518,012	218,684	1,739,980	2.4	503,801	78,157	1,195,986	14.4	18.3	3.10	1.42	3.5	48⅛–32⅝	13.0
1976	1,340,588	200,171	1,570,321	2.3	471,483	66,694	1,065,529	14.9	18.8	2.90	1.25	2.4	60–43	17.8

a Excludes nonrecurring net gain on sale of fragrance business of $528,000 ($0.28 per share). b Includes net charge on sales and disposals of assets of $21.1 million. c Includes net gain on sales of European ethylene derivatives business and other businesses of $54.4 million. d Includes net gain on sales and disposals of assets of $17.8 million. e Includes net gain on sales and disposals of assets of $16.8 million. f From continuing operations; excludes net loss from discontinued and disposed operations of $16.7 million ($0.62 per share). g Includes net gain on sale of animal health business of $1.8 million ($0.02 per share). h Includes net gain on sale of blood products business of $3.3 million ($0.03 per share). i Includes net gain on sale of assets of $450,000. j Includes net gain on sale of enzyme facilities of $700,000.

Money figures in thousands of dollars unless otherwise indicated

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME % of sales	NET INCOME % of net worth	NET INCOME $ per share	Dividends, $ per share	Dividend yield, % of price	Stock price range, $ per share	Price-earnings ratio
Merck & Co.														
1979	$2,384,627	$381,776	$2,614,064	2.2	$1,027,644	$170,134	$1,665,496	16.0%	22.9%	$5.06	$1.90	2.8%	$74¼-62½	13.5
1978	1,981,440	307,534	2,251,348	2.4	924,179	155,853	1,455,135	15.5	21.1	4.07	1.70	2.9	66¼-47⅜	14.3
1977	1,724,410	277,525[a]	1,993,389	2.5	846,784	177,167	1,277,753	16.1	21.7	3.67[a]	1.50	2.5	68¼-50	16.1
1976	1,661,514	255,482	1,791,883	2.3	747,107	153,894	1,102,154	15.4	23.2	3.38	1.40	1.9	81½-62⅝	21.3
Morton-Norwich Products														
1979[b]	$731,984	$46,088	$566,039	2.6	$223,224	$48,593	$297,777	6.3%	15.5%	$3.40	$1.26	4.2%	$34⅛-25¾	8.8
1978[b]	656,733	36,938	504,465	3.2	195,337	29,139	272,027	5.6	13.6	2.85	1.11	3.8	34⅞-23½	10.2
1977[b]	609,303	31,683	457,851	3.0	188,100	29,702	229,642	5.2	13.8	2.51	0.91	3.8	29½-18⅜	9.5
1976[b]	563,710	25,892[c]	417,832	3.5	179,011	46,726	205,245	4.6	12.6	2.06[c]	0.88	5.0	21⅝-13⅜	8.5
Pfizer Inc.														
1979	$2,746,025	$237,866	$2,945,280	2.0	$759,269	$133,300	$1,310,074	8.7%	18.2%	$3.26	$1.32	3.7%	$41¾-29	10.9
1978	2,362,133	206,256	2,643,611	2.0	709,957	110,100	1,149,537	8.7	17.9	2.93	1.17	3.6	39 -25½	11.0
1977	2,031,925	175,395	2,266,825	1.9	681,213	91,100	1,042,764	8.6	16.8	2.50	0.99	3.7	29½-23⅝	10.6
1976	1,887,507	159,928	2,103,133	2.2	661,666	82,000	952,844	8.5	16.8	2.28	0.86	3.0	31⅛-25⅜	12.4
Richardson-Merrell														
1979[b]	$1,090,546	$62,956	$718,229	2.1	$209,251	$47,545	$376,852	5.8%	16.7%	$2.66	$1.06	4.5%	$27 -19⅝	8.8
1978[b]	944,961	66,179	631,801	2.0	192,413	29,681	333,005	7.0	19.9	2.80	0.90	3.5	31 -19⅞	9.1
1977[b]	836,004	57,180	564,287	2.5	171,283	27,550	314,701	6.8	18.2	2.42	0.70	3.1	26¼-18¾	9.3
1976[b]	745,877	48,376	508,306	2.3	161,580	20,407	271,738	6.5	17.8	2.05	0.64	2.6	27⅜-21⅛	11.9
A. H. Robins Co.														
1979	$386,425	$44,746[d]	$329,072	2.8	$59,994	$16,687	$222,148	11.6%	20.1%	$1.71[d]	$0.40	4.0%	$12 -8¼	5.9
1978	357,070	29,916	273,895	3.6	55,350	12,643	188,097	8.4	15.9	1.15	0.34	3.2	12⅞-8⅝	9.3
1977	306,713	26,801	233,401	3.4	49,751	11,601	165,598	8.7	16.2	1.03	0.32	2.7	14¼-9½	11.5
1976	284,925	31,355	209,709	3.9	39,066	5,443	147,843	11.0	21.2	1.20	0.30	2.7	12¾-9½	9.3
Schering-Plough Corp.														
1979	$1,434,022	$222,267	$1,534,245	2.0	$415,401	$68,316	$1,037,354	15.5%	21.4%	$4.12	$1.39	4.4%	$35¼-27½	7.6
1978	1,082,493	193,629	1,183,919	2.7	319,551	51,336	848,558	17.9	22.8	3.62	1.21	3.8	38 -26¼	8.9
1977	940,859	166,652	1,055,087	2.4	295,284	51,572	803,675	17.7	20.7	3.08	1.09	3.0	44¾-27⅞	11.8
1976	871,537	157,094	936,548	2.6	269,255	57,509	694,585	18.0	22.6	2.91	0.94	1.9	60¼-40	17.2
G. D. Searle & Co.														
1979	$898,369	$89,004[e]	$1,099,383	1.9	$212,972	$49,253	$456,358	9.9%	19.5%	$1.66[e]	$0.52	3.3%	$20 -11½	9.5
1978	848,380	72,187	964,962	3.1	179,710	40,413	414,983	8.5	17.4	1.37	0.52	3.8	16⅜-10⅝	9.9
1977	846,931	30,610[f]	949,857	2.3	191,662	43,873	371,346	3.6	8.2	0.59[f]	0.52	4.2	13¾-10⅞	20.9
1976	761,375	61,519	990,855	2.4	170,863	36,343	413,667	8.1	14.9	1.18	0.52	3.6	18 -10¾	12.2
SmithKline Corp.														
1979	$1,351,145	$233,837	$1,150,260	2.3	$289,847	$93,494	$667,468	17.3%	35.0%	$3.85	$1.32	2.6%	$63¼-38½	13.2
1978	1,112,039	164,075	894,224	2.4	224,929	75,579	503,770	14.8	32.6	2.72	0.78	2.1	51¼-23⅛	13.6
1977	780,337	89,271	702,199	2.4	176,936	45,216	376,260	11.4	23.7	1.49	0.54	2.7	25¼-15⅜	13.6
1976	673,501	72,027	620,770	2.4	150,507	30,045	315,222	10.7	22.8	1.21	0.50	2.8	20⅝-14⅝	14.6
Squibb Corp.														
1979	$1,782,894	$123,722	$1,747,688	2.2	$630,047	$109,970	$881,875	6.9%	14.0%	$2.71	$1.095	3.3%	$39¼-27	12.2
1978	1,515,882	117,255	1,541,165	2.2	559,090	108,046	793,219	7.7	14.8	2.60	1.035	3.5	37⅜-21⅝	11.3
1977	1,341,583	112,508	1,392,269	2.2	486,519	109,332	721,000	8.4	15.6	2.50	0.975	3.8	30½-21⅝	10.4
1976	1,214,509	108,160	1,200,772	2.5	408,207	59,438	651,046	8.9	16.6	2.40	0.915	2.8	38⅞-26¼	13.6
Sterling Drug														
1979	$1,500,692	$111,594	$1,105,581	2.3	$260,594	$58,186	$680,649	7.4%	16.4%	$1.85	$0.82	4.5%	$21⅜-15¼	9.9
1978	1,314,630	94,675	959,470	2.5	255,603	36,933	618,767	7.2	15.3	1.57	0.75	4.7	19¼-12¾	10.2
1977	1,183,569	85,829	871,869	2.5	244,498	38,640	567,895	7.3	15.1	1.43	0.70	4.6	17 -13⅛	10.5
1976	1,095,753	82,759	797,308	2.5	214,190	33,826	521,831	7.6	15.9	1.39	0.70	3.9	21 -15	12.9
Upjohn Co.														
1979	$1,508,025	$149,478	$1,403,734	2.1	$476,367	$77,498	$743,659	9.9%	20.1%	$5.03	$1.62	3.6%	$50½-40	9.0
1978	1,328,551	129,405	1,207,625	2.3	437,803	44,681	639,753	9.7	20.2	4.36	1.37	3.1	56 -32⅛	10.1
1977	1,134,325	91,521	1,048,179	2.6	429,305	41,425	548,989	8.1	16.7	3.09	1.17	3.4	38⅞-30	11.1
1976	1,025,536	77,579	959,300	2.6	420,513	53,815	490,336	7.6	15.8	2.62	1.02	2.5	48½-34⅛	15.8
Warner-Lambert Co.														
1979	$3,217,208	$123,340[g]	$2,542,167	1.9	$775,253	$155,473	$1,067,151	3.8%	11.6%	$1.55[g]	$1.29	5.8%	$26½-17¾	14.3
1978	2,878,496	207,947	2,318,839	2.0	715,880	133,748	1,026,713	7.2	20.3	2.61	1.175	4.2	32½-22⅞	10.6
1977	2,542,728	187,616	1,965,969	2.6	590,014	103,494	1,117,896	7.4	16.8	2.36	1.075	3.9	31⅝-23⅞	11.8
1976	2,349,198	159,661	1,870,387	2.8	511,442	82,535	1,125,476	6.8	14.2	2.01	0.98	3.0	38½-27½	16.4

[a] Excludes extraordinary net gain on sale of Calgon consumer products business of $13.2 million ($0.18 per share). [b] Fiscal year ends June 30. [c] From continuing operations; excludes net loss from nonrecurring and extraordinary items of $32.6 million ($2.59 per share). [d] Includes income, before taxes, from settlement of antitrust litigation of $28.9 million. [e] From continuing operations; excludes net loss from operations of divested diagnostic businesses of $1.1 million ($0.02 per share). [f] Excludes provision for loss on disposal of assets of businesses being divested of $59.0 million ($1.12 per share). [g] Includes net nonrecurring charges and tax settlement of $64 million ($0.80 per share).

Productivity growth, capacity use may pose problems

Despite the chemical industry's strong profits in 1979 and early 1980, other measures of performance don't show up as well. Some important indicators of efficiency, in fact, are hinting at either short- or long-term problems.

One long-term problem for the chemical industry, as for most U.S. manufacturing, lies in labor productivity and unit labor costs. In 1979, productivity was up 5% in the chemicals and allied products industry and just 2% in all manufacturing. Both of these increases are below average for the past 10 years.

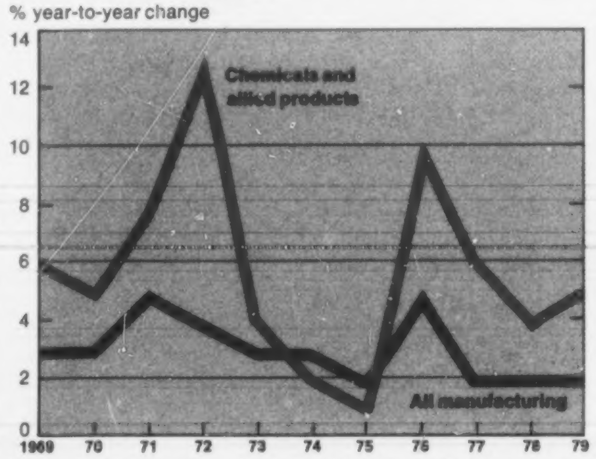
At the same time, large increases in hourly pay last year pushed up unit labor costs: 4% in chemicals and allied products and 6% for all manufacturing.

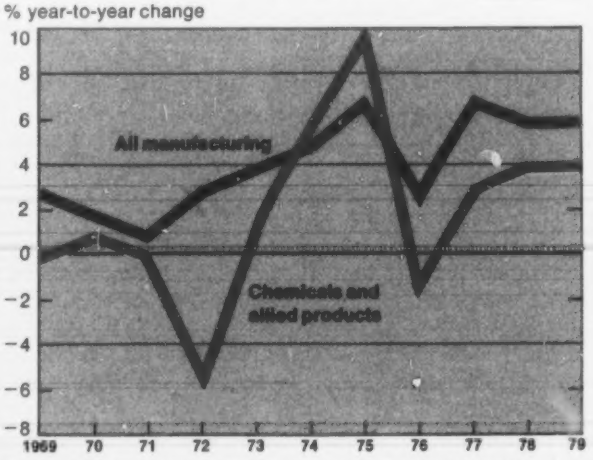
In addition, operating rates in the chemical industry's plants peaked at a high 82% of nameplate capacity in mid-1979 for the more basic chemical products. By the first quarter of 1980, they had declined to 79% as production of many products stopped expanding and some new plant capacity came on stream. This lower rate suggests that the industry may not enjoy this year the considerable economic efficiencies that it had from high plant use in 1979.

PRODUCTIVITY: Chemical industry does considerably better than average for all manufacturing

Indexes, 1967 = 100	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969
CHEMICALS AND ALLIED PRODUCTS											
Production	210.4	197.4	185.7	170.9	147.2	159.4	154.4	143.6	125.9	120.4	118.4
Workhours	108.3	106.2	104.2	101.4	96.5	105.1	103.7	100.3	99.2	102.0	105.6
Productivity	194.3	185.9	178.2	168.5	152.5	151.7	149.0	143.2	126.9	118.0	112.1
Hourly production wages	244.8	226.1	207.4	190.7	173.9	157.4	145.5	137.4	128.0	119.0	111.9
Unit labor costs	126.0	121.6	116.4	113.2	114.0	103.8	97.7	96.0	101.0	100.9	99.8
ALL MANUFACTURING											
Production	153.2	146.8	138.4	130.3	116.3	129.4	129.8	118.9	108.2	106.4	111.0
Workhours	103.9	101.7	98.0	94.2	88.6	100.9	104.0	98.1	93.0	96.3	103.3
Productivity	147.5	144.4	141.2	138.3	128.3	124.8	121.2	116.3	110.5	107.5	104.3
Hourly production wages	237.2	218.8	201.4	185.1	171.3	156.7	145.0	135.5	126.6	118.8	113.1
Unit labor costs	160.8	151.5	142.6	133.8	130.5	122.1	116.2	111.8	108.9	107.5	105.2

Sources: Department of Labor, Federal Reserve Board, C&EN calculations


Productivity edges up for chemicals . . .


. . . while unit labor costs rise at steady rate

Note: Productivity is output per workhour, calculated by dividing indexes for production by indexes for workhours of production employees. Unit labor costs are labor costs per unit of output, calculated by dividing indexes for wages by indexes for output per workhour. **Sources:** Department of Labor, Federal Reserve Board, C&EN calculations

OPERATING RATES: Use of plant capacity for basic chemicals has fallen from 1979 peak

Billions of lb per year unless otherwise noted[a]	1ST-QTR 1980		3RD-QTR 1979		1ST-QTR 1979		3RD-QTR 1978		1ST-QTR 1978		3RD-QTR 1977	
	Capacity[b]	Use	Capacity[b]	Use	Capacity[b]	Use	Capacity[b]	Use	Capacity[b]	Use	Capacity[b]	Use
ORGANIC CHEMICALS												
Benzene (bg)	2.6	70%	2.3	77%	2.3	70%	2.2	67%	2.2	73%	2.0	75%
Butadiene[c]	4.7	75	4.0	90	4.3	78	4.3	82	4.3	82	3.8	79
Cyclohexane	3.2	85	3.2	78	3.2	76	3.2	63	3.2	72	2.9	79
DMT-PTA[d]	7.3	75	7.3	68	7.3	68	6.6	72	6.5	72	6.4	77
Ethylene	39.8	78	36.5	89	35.2	85	32.5	80	32.5	79	30.1	81
Formaldehyde, 37% solution	8.5	72	8.5	79	8.5	79	8.7	74	8.7	74	8.8	67
Methanol (bg)	1.35	83	1.4	85	1.4	78	1.4	71	1.4	79	1.3	69
Phenol	3.6	81	3.4	82	3.4	82	3.5	75	3.5	69	3.0	80
Propylene, chemical	23.4	62	20.5	72	20.0	72	19.0	68	19.0	68	17.6	72
Propylene oxide	3.0	66	3.0	83	3.0	85	3.0	67	3.0	67	2.6	73
Styrene	9.3	87	8.4	89	8.2	88	8.7	80	8.7	83	8.2	83
Urea	7.7	86	7.5	87	7.5	80	6.2	82	7.3	62	6.4	70
Vinyl chloride	8.7	89	8.4	99	8.8	90	8.8	71	7.8	80	7.0	86
***p*-Xylene**	5.3	70	5.7	79	4.3	84	4.3	71	4.5	71	4.5	80
INORGANIC CHEMICALS												
Ammonia (mt)	20.4	95	20.4	91	21.0	74	19.0	88	22.4	75	21.5	79
Carbon black	4.3	74	4.3	73	4.3	91	4.0	83	4.0	83	4.0	80
Carbon dioxide (ttd)	14.1	69	12.5	52	12.5	65	15.7	51	11.5	50	14.7	51
Chlorine (mt)	14.4	84	14.4	88	14.3	83	13.9	81	13.7	76	13.5	77
Nitrogen **Oxygen** } total, liquid (ttd)	32.4	68	31.2	67	30.7	67	31.5	57	25.0	77	27.7	70
Phosphoric acid, (P_2O_5) (mt)	11.0	94	9.8	94	10.2	95	9.8	88	9.8	84	9.9	87
Phosphorus (mt)	0.55	83	0.55	78	0.55	83	0.55	82	0.55	78	0.55	70
Sodium carbonate (mt)	9.7	85	9.1	92	8.6	90	9.4	87	9.4	97	9.8	83
Sodium hydroxide (mt)	15.5	79	15.1	85	15.0	76	14.6	77	14.4	79	14.0	79
Sulfuric acid (mt)	57.5	76	56.0	81	56.0	75	55.5	67	55.3	63	54.5	61
Titanium dioxide (mt)	1.04	75	0.88	88	0.88	82	0.94	80	0.94	77	0.96	76
AVERAGE		**79%**		**82%**		**80%**		**75%**		**75%**		**76%**

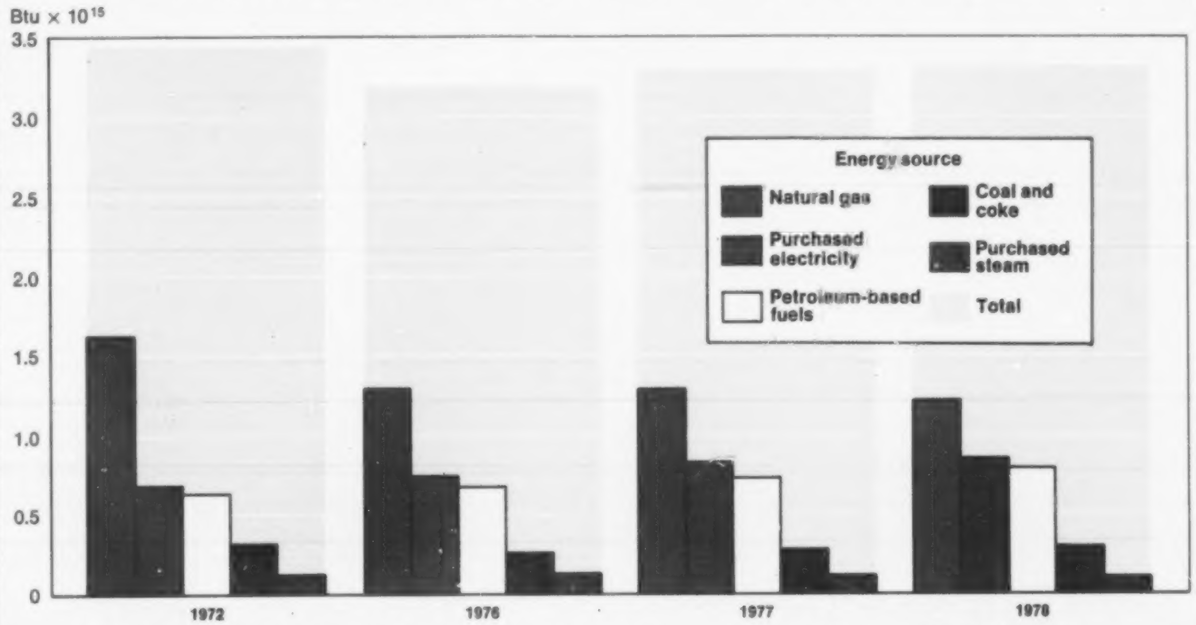
a bg = billions of gallons, mt = millions of tons, ttd = thousands of tons per day, mlt = millions of long tons. **b** Nameplate capacity. **c** Based on extraction capacity of steam-cracking plants and dehydrogenation capacity only of dehydrogenation producers; capacity could be more if extraction capacity of dehydrogenation plants were included. **d** Dimethyl terephthalate-purified terephthalic acid, not including acid converted to dimethyl terephthalate. **Sources:** Industry sources, C&EN estimates

Plant utilization also is down slightly for industry overall

	Operating rate, % of nameplate capacity, as of December										
	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969
Chemicals	83%	83%	76%	78%	78%	81%	88%	85%	81%	80%	84%
Paper	91	89	87	85	85	84	93	91	87	86	92
Petroleum	86	91	91	93	91	90	95	94	93	95	98
Rubber	70	84	81	85	81	77	84	89	86	83	87
Textiles	82	85	87	84	85	69	89	91	86	81	87
All manufacturing	81	84	82	81	79	78	85	85	80	80	84

Source: Department of Commerce

Chemical industry uses slightly less energy now than before 1973 oil embargo



Note: Data from firms accounting for more than 80% of U.S. capacity for energy for fuel and process use only; exclude energy equivalent of feedstocks.
Source: Chemical Manufacturers Association

ENERGY USE BY CHEMICAL INDUSTRY: Drop for gas largely offset by electricity and oil

Energy source	1978		1977		1976		1972		Change 1972–78	
	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total
Natural gas	1237	37.1%	1306	39.4%	1310	40.9%	1632	47.3%	−394	−24.2%
Purchased electricity[a]	876	26.3	848	25.6	769	24.0	709	20.6	167	23.6
Petroleum-based fuels	800	24.0	746	22.5	697	21.7	649	18.8	151	23.3
Light hydrocarbons	370	11.1	301	9.1	377	11.7	358	10.4	12	3.4
Residual fuels	269	8.1	241	7.3	192	6.0	194	5.6	75	38.7
Distillate fuels	64	1.9	79	2.4	54	1.7	33	1.0	31	93.9
Other liquids, solids	98	2.9	124	3.8	74	2.3	64	1.9	34	53.1
Coal and coke	305	9.1	295	8.9	287	8.9	327	9.5	−22	−6.7
Purchased steam	117	3.5	120	3.6	144	4.5	133	3.9	−16	−12.0
TOTAL	**3335**	**100.0%**	**3315**	**100.0%**	**3208**	**100.0%**	**3449**	**100.0%**	**−114**	**−3.3%**

[a] Electricity is calculated as fuel value of 10,000 Btu to generate 1 kwh instead of using standard conversion factor of 3412 Btu per kwh. **Note:** Data from companies accounting for more than 80% of U.S. capacity for basic industrial chemicals; for energy and process use only, excluding energy equivalent of feedstock. **Source:** Chemical Manufacturers Association

ENERGY USE BY PETROLEUM INDUSTRY: Oil accounts for more than half

Energy source	1978		1977		1976		1972		Change 1972–78	
	Trillion Btu	%	Trillion Btu	%	Trillion Btu	%	Trillion Btu	%	Trillion Btu	%
Natural gas	676	23%	761	25%	733	26%	930	32%	−254	−27%
Purchased electricity[a]	231	8	230	8	211	8	174	6	57	33
Petroleum-based fuels	1628	54	1534	51	1438	51	1366	47	262	19
Light hydrocarbons	1287	43	1192	40	1127	40	1075	37	212	20
Residual fuels	306	10	311	10	282	10	262	9	44	17
Distillate fuels	29	1	26	1	28	1	29	1	0	0
Other fuel	6	—	4	—	0	0	0	0	6	—
Coal and coke	425	14	454	15	423	15	436	15	−11	−2
Purchased steam	38	1	38	1	14	—	na	na	na	na
TOTAL	**2998**	**100%**	**3018**	**100%**	**2819**	**100%**	**2906**	**100%**	**92**	**3%**

[a] Electricity is calculated as fuel value of 10,000 Btu to generate 1 kwh instead of using standard conversion factor of 3412 Btu per kwh. **na** = not available. **Note:** Data from companies accounting for more than 90% of U.S. petroleum refining capacity; for energy and process use only, excluding energy equivalent of feedstock. **Sources:** American Petroleum Institute, Department of Energy

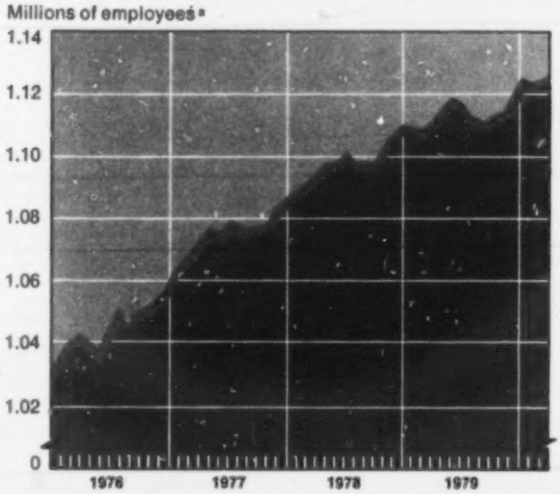
SECTION 4 EMPLOYMENT IN THE U.S. CHEMICAL INDUSTRY

Chemical employment up another notch

More people are at work in the chemical industry than ever before. The number of jobholders, in fact, has been expanding relatively steadily ever since the trough of the 1975 recession to a level now nearly 12% higher than its low point then. Not all segments of the industry have done equally well in creating new jobs, however. Since early 1975, employment has grown more than 15% in inorganic chemicals and in pharmaceuticals. But it has changed hardly at all in plants making plastics materials and synthetic fibers. In fact, the number of plastics and fibers employees is below the mid-1974 peak of more than 250,000.

Meanwhile, in recent years the chemical industry has been expanding its scientific staffs faster than employment as a whole. In the past decade, while total employment increased 5%, the number of scientists and engineers working in the industry rose nearly a fourth.

Jobs in the chemical industry climb shakily



a Seasonally adjusted employment in U.S. chemicals and allied products industry.
Source: Department of Labor

INDUSTRIAL EMPLOYMENT: Plastics production is largest source of jobs for chemical workers

	All employees[a] (thousands)				Production workers[a] (thousands)				Workweek[a,b] (hours)			
	1979	1978	1977	1969	1979	1978	1977	1969	1979	1978	1977	1969
All manufacturing	20,972	20,476	19,682	20,167	15,010	14,714	14,135	14,767	40.2	40.4	40.3	40.6
Chemicals and allied products	1,113	1,096	1,074	1,060	637	628	616	622	41.8	41.9	41.7	41.8
Industrial inorganic chemicals	171	166	162	na	93	94	95	na	42.1	42.2	41.9	na
Plastics materials and synthetics	217	216	214	240	148	146	142	148	42.1	42.4	41.8	42.2
Drugs	191	186	181	143	94	90	90	71	41.1	41.3	41.0	41.0
Soap, cleaners, and toilet goods	138	136	130	124	84	83	78	73	40.5	40.6	40.7	40.9
Paints and allied products	70	69	66	72	36	36	35	40	41.1	41.5	41.2	41.0
Industrial organic chemicals	166	166	166	na	86	86	84	na	43.4	42.5	42.7	na
Agricultural chemicals	69	68	67	na	44	42	42	na	42.9	42.6	43.0	na
Miscellaneous chemical products	91	90	87	na	51	51	50	na	41.5	41.6	41.8	na
Petroleum and coal products	214	209	202	182	140	136	131	112	43.8	43.6	42.7	42.6
Rubber and miscellaneous plastics products	768	752	714	596	601	589	558	462	40.5	40.9	41.0	41.1

a Domestic employment. b Workweek of production or nonsupervisory workers. **na** = not available **Source:** Department of Labor

EMPLOYMENT OF SCIENTISTS AND ENGINEERS: More than 10% work in chemicals

Thousands[a]	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969
Total, all industry	427.8	403.7	382.8	364.4	363.3	360.0	357.7	350.2	367.0	384.2	387.1
Chemicals and allied products	49.4	47.9	46.4	44.4	45.2	41.8	40.9	41.0	42.7	40.1	40.0
Industrial chemicals	21.8	21.5	20.6	20.1	21.1	19.1	19.1	19.1	21.8	21.5	22.3
Drugs and medicines	19.3	18.9	17.8	16.6	15.6	14.0	13.0	13.1	12.3	11.8	10.2
Other chemicals	7.6	7.4	8.0	7.8	8.5	8.7	8.8	8.8	8.6	6.8	7.5
Petroleum refining	10.8	10.0	8.9	8.6	8.4	8.2	8.2	8.3	9.2	9.9	10.0
Rubber products	na	7.9	9.1	8.6	8.4	7.7	7.5	6.7	6.7	7.4	6.6

a Full-time-equivalent number of R&D scientists and engineers in industry, as of January of each year. **na** = not available. **Source:** National Science Foundation

COMPANY EMPLOYMENT: Big gains at Allied Chemical and Grace boost industry totals

Thousands	Worldwide employment									
	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970
Air Products	14.6	14.3	13.7	13.4	13.0	13.0	10.3	9.0	9.2	9.1
Akzona	15.4	15.3	15.6	15.6	15.8	19.5	19.6	17.7	16.6	13.3
Allied Chemical	49.0	32.0	32.8	33.4	33.4	32.2	33.5	32.7	34.0	32.8
American Cyanamid	44.2	44.0	43.8	39.4	37.8	38.0	39.5	41.4	41.4	38.0
Cabot	8.1	7.9	5.6	5.6	5.6	6.3	6.6	6.6	6.9	7.2
Celanese	33.3	33.2	32.1	31.9	37.0	38.8	37.4	36.2	36.5	34.6
Crompton & Knowles	3.0	3.2	3.1	3.0	2.2	2.4	2.5	2.6	2.8	2.7
Diamond Shamrock	12.4	12.9	12.3	11.4	10.9	9.8	9.3	8.7	8.5	8.7
Dow Chemical	55.9	53.5	53.2	53.0	53.0	53.3	49.8	48.8	47.8	47.4
Du Pont	134.2	131.8	132.0	132.5	134.6	135.2	129.1	122.3	122.2	129.1
Ethyl Corp.	16.0	16.5	16.0	16.0	17.0	18.0	14.0	14.0	13.0	14.0
Ferro	9.1	8.4	8.2	7.4	7.7	8.0	7.5	6.9	6.3	5.9
Freeport Minerals	3.9	3.5	3.7	3.8	3.5	3.3	2.9	2.3	2.3	2.4
W. R. Grace	82.1	68.5	68.7	63.8	65.3	79.1	75.7	73.9	66.9	63.9
Hercules	24.4	24.5	24.0	24.0	23.5	25.3	24.1	22.4	22.1	23.2
International Flavors	3.6	3.5	3.3	3.1	2.9	3.1	2.8	2.7	2.7	2.7
International Minerals	10.3	9.9	9.9	9.7	10.5	6.6	6.2	6.2	7.0	7.8
Lubrizol	3.9	3.8	3.6	3.6	3.6	3.5	3.3	3.0	3.0	2.9
Mallinckrodt	4.8	4.9	4.3	4.3	3.9	3.7	3.1	2.9	2.8	2.9
Monsanto	63.9	62.9	61.5	61.9	59.2	60.9	58.3	57.9	59.3	62.9
Nalco Chemical	4.1	4.1	4.2	3.8	3.5	3.4	3.2	2.9	2.7	2.6
National Distillers	15.7	16.1	13.1	13.3	13.6	14.3	16.0	16.9	17.6	17.3
Olin	21.7	22.7	22.4	22.0	23.0	23.0	24.0	32.0	31.0	29.0
Pennwalt	13.3	14.0	13.9	13.9	14.3	14.8	13.9	12.8	13.0	13.4
Reichhold Chemicals	6.4	6.5	6.5	5.8	4.3	4.1	4.3	3.4	3.4	3.6
Rohm & Haas	13.3	13.1	13.0	13.3	13.8	14.2	13.5	13.1	12.7	13.0
Stauffer Chemical	13.8	13.1	13.0	13.0	13.1	12.5	12.0	11.3	10.5	11.6
Stepan Chemical	0.9	0.8	0.8	0.7	0.7	0.8	0.7	0.6	0.6	0.6
Texasgulf	5.9	5.5	5.4	5.3	4.9	4.3	4.0	3.8	3.3	3.3[a]
Union Carbide	115.8	113.4	113.7	113.1	106.5	109.6	109.4	98.1	99.2	102.1
TOTAL EMPLOYEES	**803.0**	**767.9**	**753.4**	**741.4**	**738.2**	**761.0**	**736.6**	**720.9**	**712.8**	**708.0**
ANNUAL CHANGE	**4.6%**	**1.9%**	**1.6%**	**0.4%**	**−3.0%**	**3.3%**	**2.2%**	**1.1%**	**0.7%**	**−3.0%**
SALES PER EMPLOYEE ($ thousands)	**$97.2**	**$89.9**	**$75.9**	**$69.7**	**$54.2**	**$58.5**	**$46.2**	**$41.2**	**$36.1**	**$34.6**

a C&EN estimate.

WAGES: More than doubled in a decade for blue-collar workers

	Hourly earnings[a]				Weekly earnings[a]			
	1979	1978	1977	1969	1979	1978	1977	1969
All manufacturing	$6.69	$6.17	$5.68	$3.19	$268.94	$249.27	$228.90	$129.51
Chemicals and allied products	7.59	7.01	6.43	3.47	317.26	293.72	268.13	145.05
Industrial inorganic chemicals	8.26	7.63	6.99	na	347.75	321.99	292.88	na
Plastics materials and synthetics	7.41	6.87	6.29	3.40	311.96	291.29	262.92	143.48
Drugs	6.94	6.42	5.99	3.30	285.23	265.15	245.59	135.63
Soap, cleaners, and toilet goods	7.18	6.69	6.13	3.42	290.79	271.61	249.49	139.88
Paints and allied products	6.78	6.34	5.91	3.29	278.66	263.11	243.49	134.89
Industrial organic chemicals	9.01	8.22	7.42	na	391.03	349.35	316.83	na
Agricultural chemicals	7.29	6.68	6.03	na	312.74	248.57	259.29	na
Miscellaneous chemical products	7.07	6.54	6.02	na	293.41	272.06	251.64	na
Petroleum and coal products	9.37	8.63	7.83	4.00	410.41	376.27	334.34	170.40
Rubber and miscellaneous plastics products	5.96	5.52	5.17	3.07	241.38	225.77	211.97	126.18

a For production and nonsupervisory workers in domestic employment. **na** = not available. **Source:** Department of Labor

U.S. chemical trade surplus near $10 billion

Chemicals continue to be one of the few bright spots in an overall dismal U.S. trade picture. Although the deficit in the U.S. balance of trade last year, $24.7 billion, was an improvement over the $28.5 billion deficit in 1978, it is still a lot of red ink, thanks in large measure to increasingly expensive oil imports.

But those same high world oil prices that contributed to the U.S. trade deficit proved to be a boon to U.S. chemical exporters. With their feedstock costs based on lower domestic oil prices and even less expensive light feeds from natural gas, they managed to increase chemical exports a whopping 37%.

Last year's chemical exports hit a record $17.3 billion and with imports growing only 16.5% to $7.5 billion, the U.S. chemical industry was able to boost its trade surplus to $9.8 billion, also a new record.

By comparison, West Germany, which is the world's largest single chemical exporting country with $22.4 billion in such shipments, managed to raise its chemical exports only 16.5% last year. And while West Germany's share of the world chemical export market was slipping, the U.S. share increased, from 14.4% in 1978 to 15.1% last year.

However, the feedstock cost advantage that contributed so strongly to last year's strong export performance by the U.S. chemical industry also has created problems. Stung by increasingly large shipments of synthetic fibers from the U.S., particularly to Britain and Italy, the European Economic Community and some individual members have taken steps to curb imports. Quotas have been imposed and antidumping duties have been applied.

The U.S.-EEC trade hassle now is spilling over into chemicals. U.S. imports of liquid nitrogen fertilizer, vinyl acetate, and styrene already are under investigation in EEC.

U.S. TOTAL TRADE BALANCE:
Three years of deep deficit

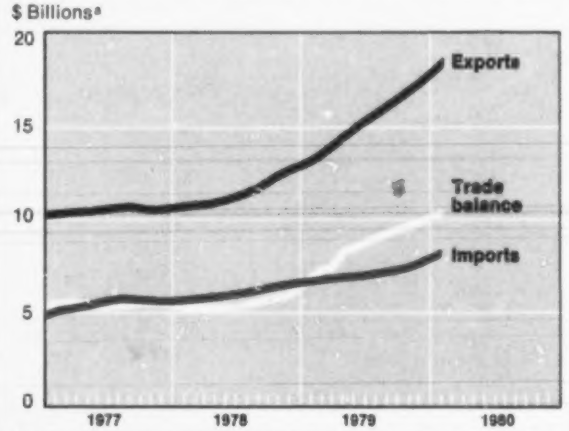
$ Millions	1979	1978	1977	1969
Exports[a]	$181,639	$143,575	$121,150	$37,322
Imports[b]	206,327	172,026	147,685	36,043
Trade balance	−24,688	−28,451	−26,535	1,289

U.S. CHEMICAL TRADE BALANCE:
One year of strong improvement

$ Millions	1979	1978	1977	1969
Chemical exports[c]	$ 17,306	$ 12,618	$ 10,827	$ 3,383
Chemical imports[b]	7,485	6,427	5,432	1,232
Chemical trade balance	9,821	6,191	5,395	2,151

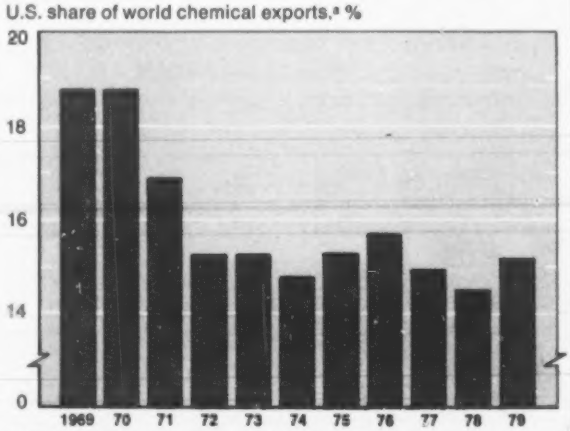
a Exports of domestic and foreign merchandise, excluding Department of Defense and Grant-Aid shipments. FAS value (free alongside ship). b General imports. Starting in 1974 reported as FAS value. Prior to 1974 reported as foreign value, which is within 1% of FAS value. c Exports of domestic merchandise, including Department of Defense and Grant-Aid shipments. **Source:** Department of Commerce

U.S. chemical trade balance rises sharply



a Running 12-month values for U.S. chemical exports, imports, and trade balance. **Source:** Department of Commerce

U.S. chemicals hold share of world market



a U.S. exports as a percentage of world chemical exports less U.S. imports. **Source:** C&EN estimates based on Department of Commerce and United Nations data

WORLD TRADE: West Germany keeps lead

$ Millions	1979	1978	1977	1969
CHEMICAL EXPORTS				
World	$122,500[a]	$94,053	$77,890	$21,880
U.S.	17,306	12,618	10,827	3,383
Canada	2,995	2,111	1,696	456
EC, nine countries[b]	68,038	52,078	43,362	10,015
Belgium-Luxembourg	6,644	5,701	4,620	809
France	11,632	8,835	7,162	1,589
Italy	4,532	3,710	3,156	820
Netherlands	10,315	7,425	6,321	1,297
U.K.	10,405	8,064	6,753	1,644
West Germany	22,397	18,835	14,216	3,590
Switzerland	4,885	4,804	3,580	986
Japan	6,100	5,102	4,300	1,016
CHEMICAL IMPORTS				
World	—	—	—	—
U.S.	7,485	6,427	5,432	1,232
Canada	3,340	2,556	2,347	703
EC, nine countries[b]	50,382	36,682	30,273	7,114
Belgium-Luxembourg	5,352	4,627	3,359	725
France	9,847	7,280	5,948	1,349
Italy	6,898	4,725	3,776	975
Netherlands	5,752	4,175	3,635	917
U.K.	7,292	5,293	4,303	1,111
West Germany	12,388	8,785	7,503	1,560
Switzerland	2,870	2,421	2,012	545
Japan	5,178	3,763	3,003	783

a C&EN estimate. b European Communities; historical data have been adjusted to reflect present nine member countries. **Sources:** United Nations, Organization for Economic Cooperation & Development, European Communities, individual country data

U.S. TRADE: Europe takes a third

$ Millions	1979	1978	1977	1969
U.S. CHEMICAL EXPORTS				
Canada	$ 1,991	$ 1,739	$ 1,539	$ 510
Western Europe	5,585	4,275	3,737	1,239
Eastern Europe	200	62	78	35
Communist Asia	125	61	20	—
Japan	1,652	1,104	977	304
Rest of Asia	2,204	1,324	955	337
Middle East	387	367	269	55
Latin America	3,814	2,679	2,350	613
Australasia	608	417	384	96
Africa	465	349	309	101
Other	272	241	209	93
TOTAL	**$17,306**	**$12,618**	**$10,827**	**$3,383**
U.S. CHEMICAL IMPORTS				
Canada	$2362	$1805	$1451	$310
Western Europe	3449	3227	2465	538
Eastern Europe	107	78	33	8
Communist Asia	60	34	22	0
Japan	616	563	465	121
Rest of Asia	148	124	89	13
Middle East	48	41	35	3
Latin America	405	312	212	58
Australasia	158	115	402	91
Africa	49	46	46	20
Other	83	82	212	70
TOTAL	**$7485**	**$6427**	**$5432**	**$1232**

Source: Department of Commerce

U.S. CHEMICAL EXPORTS:[a] Plastics surge

	$ Millions			
Classification	1979[b]	1978[b]	1977	1969
Organic chemicals	$5,055	$3,369	$3,286	$968
Inorganic chemicals	1,712	1,207	1,047	374
Uranium, thorium, cerium, radioactive and nonradioactive; isotopes	973	717	551	103
Dyeing, tanning, and coloring materials	177	145	126	36
Pigments, paints, and varnishes	273	241	227	85
Medicinals and pharmaceuticals	1,591	1,404	1,080	363
Flavors, perfumes, cosmetics, and toiletries	399	356	274	83
Cleaning and polishing materials	290	250	195	79
Fertilizers, manufactured	1,404	1,091	701	218
Explosives and pyrotechnics	62	65	78	17
Plastics and resins	3,241	2,088	1,732	590
Pesticides and disinfectants	516	445	c	c
Miscellaneous	1,649	1,240	1,530	467
TOTAL	**$17,306**	**$12,618**	**$10,827**	**$3,383**

a Exports of domestic merchandise, including Department of Defense and Grant-Aid shipments. FAS (free alongside ship) value. b As a result of statistical reclassification, 1978 and 1979 data are not directly comparable to those of previous years. C&EN has rearranged past data to make them as comparable as possible. c Included in miscellaneous. **Source:** Department of Commerce

U.S. CHEMICAL IMPORTS:[a] Organics are top

	$ Millions			
Classification	1979[b]	1978[b]	1977	1969
Organic chemicals	$2159	$1734	$1437	$322
Inorganic chemicals	1106	915	1175	303
Uranium, thorium, cerium, radioactive and nonradioactive; isotopes	953	912	484	28
Dyeing, tanning, and coloring materials	185	171	142	74
Pigments, paints, and varnishes	76	63	44	9
Medicinals and pharmaceuticals	441	449	318	83
Flavors, perfumes, cosmetics, and toiletries	263	230	175	64
Cleaning and polishing materials	73	62	49	10
Fertilizers, manufactured	976	869	829	137
Explosives and pyrotechnics	58	43	36	35
Plastics and resins	626	518	389	99
Pesticides and disinfectants	190	159	c	c
Miscellaneous	379	303	354	68
TOTAL	**$7485**	**$6427**	**$5432**	**$1232**

a General imports, FAS (free alongside ship) value. b As a result of a statistical reclassification, 1978 and 1979 data are not directly comparable to those of previous years. C&EN has rearranged past data to make them as comparable as possible. c Included in miscellaneous. **Source:** Department of Commerce

WESTERN EUROPE
SECTION 6
FOREIGN CHEMICAL INDUSTRIES

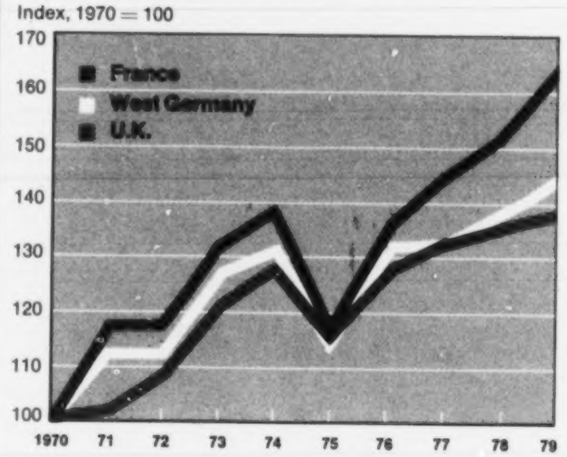
Managers of European chemical companies were pleasantly surprised with the outcome of business last year. Instead of the downturn that had been widely feared, sales moved ahead.

There were complaints that profit margins weren't higher. But after-tax profits generally were up from 1978. Of 17 major West European companies, only four had a decline. Italy's Montedison's profit last year, though modest, was a heartening turnaround from the losses of the four previous years. There were strong gains, meanwhile, by Akzo, DSM, UCB, and Rhône-Poulenc.

Chemical prices and production rose in France, West Germany, and the U.K. in 1979. The number of workers employed in chemical plants increased a few thousand in the U.K., remained about the same in West Germany, and fell about 5000 in France.

Man-made fibers continued to be a problem area, however. Production of noncellulosics throughout Western Europe last year totaled about 5.2 billion lb, against 5.1 billion lb in 1978. Cellulosics output remained unchanged at about 1.9 billion lb.

Chemical production continues to rise



PRODUCTION: Declines were few for major chemicals in 1979

Millions of lb	1979	1978	1977	1976	Change 1978–79
U.K.					
Sulfuric acid	7,696	7,599	7,489	7,192	1%
Hydrochloric acid	299[a]	290	308	304	3
Chlorine	2,237[a]	2,112	2,275	2,319	6
Ethylene	2,523[a]	2,411	2,504	2,829	5
Benzene	2,442[a]	1,947	2,136	2,323	25
Phenol	407[a]	372	370	407	9
Phthalic anhydride	213[a]	200	218	220	7
Carbon black	453[a]	438	425	471	3
Plastics	3,632[a]	3,491	3,509	3,529	4
Polyethylene	1,014[a]	942	1,074	1,043	8
Polypropylene	616[a]	642	546	552	−4
Polystyrene	486[a]	460	504	526	6
Polyvinyl chloride	937[a]	902	849	917	4
Synthetic rubber	662[a]	645	704	704	3
Nitrogen fertilizers (N)	1,483[a]	1,313	1,393	1,199	13
Phosphate fertilizers (P_2O_5)	942[a]	920	990	880	2
Detergents	1,973[a]	1,734	1,714	1,659	14
WEST GERMANY					
Sulfuric acid	9,046	8,400	8,404	8,411	8%
Chlorine	7,075	6,624	6,193	6,173	7
Ammonia	4,754	4,301	4,376	4,099	11
Sodium carbonate	3,038	2,699	2,955	3,007	13
Sodium sulfate	458	464	530	563	−1
Ethylene	7,803	7,093	6,525	6,116	10
Benzene	2,537	1,967	1,813	2,020	29
Toluene	647	497	535	513	30
Xylenes	1,078	913	997	1,052	18
Phthalic anhydride	587	590	539	559	−1
Methanol	1,890	1,771	1,956	2,314	7
Carbon black	750	656	664	642	14
Plastics	15,917	14,835	13,730	14,175	7
Polyethylene	3,500	3,348	3,155	3,234	5
Polyvinyl chloride	2,394	2,213	1,973	2,123	8
Synthetic rubber	977	926	955	834	6
Detergents	3,302	3,051	2,823	2,831	8
Dyes, organic	323	299	297	332	8
Pigments, inorganic	2,323	2,182	2,125	1,989	7
Pesticides	502	497	449	414	1
Nitrogen fertilizers (N)	2,961	2,781	2,867	2,743	7
Phosphate fertilizers (P_2O_5)	1,547	1,553	1,593	1,536	0
FRANCE					
Sulfuric acid	10,798	10,096	9,898	8,710	7%
Hydrochloric acid	1,566	1,509	1,481	1,364	4
Chlorine	2,867	2,779	2,713	2,644	3
Sodium hydroxide	3,142	2,948	2,913	2,742	7
Ammonia	4,730	4,435	4,473	3,918	7
Sodium carbonate	3,430	2,977	2,713	2,644	15
Sodium sulfate	332	275	262	284	21
Sulfur	4,319	4,180	4,204	3,865	3
Ethylene	4,946	4,228	4,107	3,718	17
Phthalic anhydride	194	196	191	185	−1
Methanol	752	763	827	695	−1
Acetone	273	268	271	244	2
Butadiene	660	631	576	504	5
Polyethylene	2,581	2,158	2,097	1,998	20
Polypropylene	440	319	198	165	38
Polystyrene	581	449	513	535	29
Polyvinyl chloride	1,725	1,463	1,419	1,333	18
Synthetic rubber	1,164	1,080	1,054	934	8
Detergents	1,789	1,685	1,663	1,646	6
Dyes, organic	70	62	73	75	13
Phosphate fertilizers (P_2O_5)	2,845	2,660	2,664	2,182	7

[a] Estimated. **Sources:** Chemical Industries Association, Verband der Chemischen Industrie, Union des Industries Chimiques

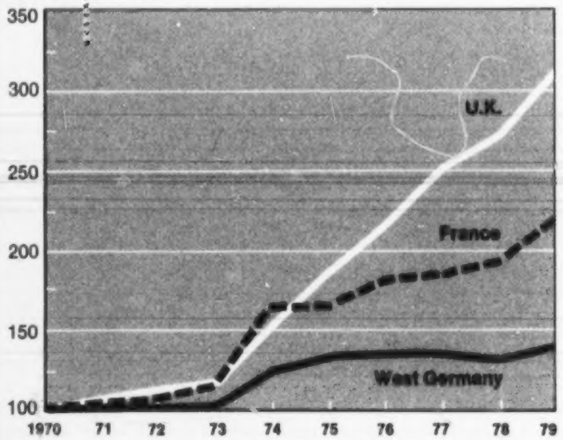
SYNTHETIC FIBERS: Supply/demand pattern is mixed in Western Europe

Millions of lb	1979		1978		1977		1976		Change, 1978–79	
	Non-cellulosics	Cellulosics	Non-cellulosics	Cellulosics	Non-cellulosics	Cellulosics	Non-cellulosics	Cellulosics	Non-cellulosics	Cellulosics
PRODUCTION										
West Germany	1725	295	1642	293	1568	290	1710	305	5%	1%
Italy	988	156	888	190	830	235	887	234	11	−18
U.K.	838	504	885	478	791	460	911	481	−5	5
France	493	169	542	163	532	179	547	186	−9	4
Spain	466	128	416	133	351	128	327	125	12	−4
Benelux countries	286	165	292	165	295	156	314	151	−2	0
Switzerland	185	7	183	9	171	10	172	10	1	−27
Turkey	na	na	182	10	177	10	98	9	na	na
Ireland	88^a	—	68	—	35	—	39	—	29	—
Portugal	66^a	7	62	5	36	6	26	6	7	25
Austria	62	242	67	236	57	226	60	228	−6	3
Greece	na	na	36	16	33	16	29	15	na	na
Finland	—	99	—	96	—	90	—	70	—	3
Sweden	—	73	—	77	—	73	—	67	—	−6
Norway	—	64	—	63	—	54	—	57	—	2
CONSUMPTION										
West Germany	959^a	337^a	890	327	872	316	914	346	8	3
Italy	1053^a	217^a	880	185	725	211	876	219	20	17
U.K.	1033^a	326^a	875	303	799	231	873	316	18	7
France	387^a	150^a	549	138	496	136	568	154	−30	8
Spain	493^a	120^a	463	141	428	127	480	130	7	−15
Benelux countries	314^a	123^a	315	132	326	136	328	151	0	−7
Switzerland	74^a	24^a	60	19	60	22	63	22	24	24
Ireland	49^a	9^a	49	5	42	6	22	7	−10	67
Portugal	123^a	32^a	107	26	95	41	103	38	15	27
Austria	120^a	68^a	143	64	128	61	131	65	−16	6
Greece	91^a	18^a	80	16	85	22	90	19	13	11
Finland	47^a	47^a	37	12	32	12	32	19	27	300
Sweden	38^a	15^a	43	12	43	18	54	35	−11	26
Norway	26^a	25^a	20	6	21	6	22	18	35	300
Denmark	32^a	4^a	35	5	36	5	45	6	−6	−27

a C&EN estimates. **Note:** consumption = production plus imports less exports. **Source:** Comité International de la Rayonne et des Fibres Synthétiques

Prices on chemicals are marked higher

Index, 1970 = 100



Sources: Chemical Industries Association, Verband der Chemischen Industrie, Union des Industries Chimiques

INDUSTRY TRENDS: Sales up strongly

$ Billions	1979	1978	1977	1976	1975
U.K.					
Sales	$39.7	$29.3	$25.9	$19.2	$17.9
Exports	11.0	8.6	7.3	5.2	4.4
Imports	7.6	5.6	4.5	3.4	2.8
Capital spending	2.4	2.2	1.6	1.2	1.1
Employees (thousands)	438	435	431	425	431
WEST GERMANY					
Sales	$59.2	$48.9	$40.9	$35.7	$30.2
Exports	25.4	20.2	16.8	14.7	11.0
Imports	13.9	10.4	8.7	7.4	5.4
Capital spending	2.8	3.1	2.6	2.4	2.1
Employees (thousands)	548	548	553	556	578
FRANCE					
Sales	$34.9	$27.5	$22.6	$19.3	$18.7
Exports	12.2	8.9	6.9	5.9	5.2
Imports	9.4	7.3	5.7	5.3	4.4
Capital spending	1.3	1.2	1.0	0.9	1.1
Employees (thousands)	301	306	307	307	303

Sources: Chemical Industries Association, Verband der Chemischen Industrie, Union des Industries Chimiques

COMPANY RESULTS: Profitability generally improved

$ Millions	Net sales	Net income	Profit margin	Capital spending	R&D spending	Employees (thousands)
Hoechst (West Germany)						
1979	$15,653.2	$375.7	2.4%	$945.1	$660.1	183
1978	13,365.2	230.4	1.7	807.2	593.4	181
1977	11,041.7	144.2	1.3	707.8	494.6	181
1976	9,951.3	245.8	2.5	711.4	409.3	183
Bayer (West Germany)						
1979	$15,030.1	$251.5	1.7%	$1294.8	$638.2	181
1978	12,616.6	258.0	2.0	954.1	564.1	179
1977	10,138.4	161.1	1.6	895.3	439.3	170
1976	8,847.5	221.6	2.5	700.0	370.8	171
BASF (West Germany)						
1979	$14,968.8	$357.8	2.4%	$1046.8	$515.6	117
1978	11,885.6	232.6	2.0	970.7	458.6	115
1977	10,023.7	183.9	1.8	784.4	370.1	114
1976	8,891.1	257.2	2.9	653.0	289.0	113
Imperial Chemical Industries (U.K.)						
1979	$11,970.6	$961.1	8.0%	$1694.8	$412.6	148
1978	9,247.3	620.2	6.7	1430.0	344.6	151
1977	8,953.0	612.5	6.8	942.7	288.0	154
1976	7,029.5	494.7	7.0	774.6	232.9	192
Montedison (Italy)						
1979	$8,498.8	$ 14.9	0.02%	$470.1	$196.5	115
1978	7,017.0	(326.9)[a]	—	650.1	$166.5	127
1977	6,275.2	(583.7)[a]	—	839.4	149.1	135
1976	5,502.9	(196.6)[a]	—	851.4	130.3	145
Rhône-Poulenc (France)						
1979	$8,403.2	$196.8	2.3%	$547.3	$323.4	102
1978	6,134.5	57.3	0.9	332.8	264.8	107
1977	5,023.6	18.1	0.4	309.8	221.1	111
1976	4,373.4	(73.2)[a]	—	293.6	195.6	113
DSM (Netherlands)						
1979	$6,710.5	$46.8	0.7%	$282.1	$71.1	32
1978	5,130.8	13.3	0.3	514.9	69.2	32
1977	4,445.2	48.2	1.1	618.9	57.0	33
1976	3,782.5	53.7	1.4	519.9	48.0	33
Akzo (Netherlands)						
1979	$6,323.7	$152.1	2.4%	$242.6	$242.1	83
1978	5,469.7	25.1	0.5	222.6	225.6	83
1977	4,575.9	(22.8)[a]	—	179.4	188.6	84
1976	4,369.9	2.4	0.1	167.9	166.7	91
Ciba-Geigy (Switzerland)						
1979	$6,220.8	$205.7	3.3%	$376.1	$518.2	80
1978	5,193.0	209.3	4.0	322.1	443.0	75
1977	4,825.7	203.9	4.2	310.7	368.9	74
1976	3,856.9	130.1	3.4	276.0	295.1	74

$ Millions	Net sales	Net income	Profit margin	Capital spending	R&D spending	Employees (thousands)
Solvay (Belgium)						
1979	$4,319.2	$167.8	3.9%	$302.3	$102.7	460
1978	3,322.5	113.8	3.4	311.3	92.6	45
1977	2,742.1	81.0	3.0	236.8	72.8	45
1976	2,447.0	136.2	5.6	196.8	62.9	44
Hoffmann-La Roche (Switzerland)						
1979	$3,264.7	$137.7	4.2%	$332.1	$406.3	43
1978	2,816.4	116.9	4.2	235.5	370.3	42
1977	2,663.3	163.1	6.1	294.2	na	40
1976	2,079.4	193.1	9.3	226.4	na	38
Sandoz (Switzerland)						
1979	$2,795.0	$108.8	3.9%	$130.2	$242.8	35
1978	2,498.3	90.7	3.6	135.5	219.8	35
1977	2,317.0	103.9	4.5	103.9	196.1	36
1976	1,670.3	58.5	3.5	91.9	148.0	33
BOC International (U.K.)						
1979	$2,740.7	$99.5	3.6%	$294.8	na	49
1978	2,440.0	72.8	3.0	272.3	na	56
1977	1,287.6	90.4	7.0	139.4	na	41
1976	1,032.9	59.7	5.8	79.6	na	41
Fisons (U.K.)						
1979	$965.6	$29.5	3.1%	$39.7	$32.1	13
1978	710.5	38.3	5.4	40.8	26.5	13
1977	563.1	31.4	5.6	34.6	20.5	12
1976	439.1	25.8	5.9	21.6	13.6	11
Albright & Wilson (U.K.)						
1979	$880.6	$37.9	4.3%	$72.7	na	10
1978	697.9	47.1	6.7	88.5	na	10
1977	649.0	54.8	8.4	47.0	na	10
1976	485.0	32.0	6.6	23.6	na	10
UCB (Belgium)						
1979	$728.0	$12.4	1.7%	$22.0	$20.5	8
1978	619.4	3.6	0.6	26.0	20.2	9
1977	519.2	(12.0)[a]	—	24.6	20.2	9
1976	470.6	5.1	1.1	23.0	16.9	10
Laporte Industries (U.K.)						
1979	$423.9	$18.3	4.3%	$35.7	na	5
1978	340.9	10.8	3.2	24.5	na	5
1977	290.9	9.6	3.3	21.1	na	5
1976	223.4	21.1	5.4	11.9	na	5

a Deficit. na = not available.

NOTE ON CURRENCY CONVERSION

For monetary statistics reports in this section, European currencies were converted to U.S. dollars by the following conversion rates:

	$1.00 (U.S.) is equivalent to:						
	U.K.	West Germany	Netherlands	Belgium	France	Italy	Switzerland
1979	0.448 pound	1.73 marks	1.90 guilders	28.01 francs	4.02 francs	804 lire	1.59 francs
1978	0.490 pound	1.81 marks	1.96 guilders	28.63 francs	4.15 francs	823 lire	1.72 francs
1977	0.521 pound	2.11 marks	2.28 guilders	33.03 francs	4.70 francs	872 lire	2.06 francs
1976	0.588 pound	2.36 marks	2.46 guilders	35.90 francs	4.97 francs	875 lire	2.46 francs
1975	0.495 pound	2.62 marks	2.69 guilders	39.58 francs	4.47 francs	684 lire	2.62 francs

JAPAN
SECTION 6
FOREIGN CHEMICAL INDUSTRIES

Seven years after the first oil crisis, the Japanese petrochemical industry is still feeling its impact.

During the past two years, buoyed by an economic recovery at home, the petrochemical industry has started to show some signs of life. Production, which started to increase in the latter part of 1978, continued to do so in 1979. Ethylene output, for instance, hit a record 4.75 million metric tons.

Actually, the situation isn't all that rosy for Japanese petrochemical producers. Naphtha prices are high and supply is short. Much of last year's surge in shipments was the result of downstream stockpiling brought on by the Iranian crisis.

Price increases gave a boost to profits, but profits still are low by most standards. Prospects for further gains are slim, moreover, because Japanese petrochemical companies are losing their competitive edge, not only in export markets but at home.

WORLD TRADE: Deficit developed in 1979

$ Millions	1979	1978	1977	1976
Total exports	$103,032	$97,543	$80,495	$67,225
Total imports	110,672	79,343	70,809	64,799
Chemical exports	6,100	5,102	4,300	3,747
Chemical imports	5,178	3,763	3,003	2,662

Source: Ministry of International Trade & Industry

INDUSTRY TRENDS: Fibers, fertilizers lag

Index, 1975 = 100	1979	1978	1977	Change 1978–79
All chemicals				
Production	143.7	131.3	117.2	9%
Shipments	143.6	130.0	117.5	10
Inventories	101.1	100.7	101.3	0
Petrochemicals				
Production	147.9	133.4	119.8	10
Shipments	147.1	131.6	117.4	12
Inventories	112.5	109.2	108.7	3
Plastics				
Production	160.4	133.4	114.8	20
Shipments	161.4	132.4	114.7	22
Inventories	99.7	91.6	93.1	9
Synthetic fibers				
Production	129.7	129.6	121.5	0
Shipments	136.2	136.9	123.9	1
Inventories	80.4	95.1	109.2	−15
Synthetic rubber				
Production	140.4	130.4	123.1	8
Shipments	131.0	122.5	118.9	7
Inventories	102.0	102.7	96.5	−1
Fertilizer				
Production	90.2	89.2	85.1	1
Shipments	99.7	96.5	98.9	3
Inventories	72.1	76.3	83.5	−6
All manufacturing				
Production	133.3	123.0	115.7	8
Shipments	130.7	121.4	114.6	8
Inventories	102.6	103.0	104.7	0

Source: Ministry of International Trade & Industry

PRODUCTION: Plastics set growth pace

Thousands of metric tons unless otherwise indicated	1979	1978	1977	1976	Change 1978–79
ORGANIC CHEMICALS					
Acetaldehyde	583	587	624	613	−1%
Acetic acid	502	518	544	550	−3
Acetone	254	261	238	233	−3
Acrylonitrile	579	609	596	633	−5
Benzene	2178	2015	1951	1878	8
Butadiene	658	658	610	601	0
Butyl alcohol	252	222	194	190	14
Caprolactam	437	427	453	473	2
Cyclohexane	509	477	515	531	7
Dioctylphthalate	259	268	236	219	−3
Ethylene	4755	4387	3979	3803	8
Ethylene dichloride	2110	1837	1723	1656	15
Ethylene glycol	572	630	523	550	−9
Ethylene oxide	593	631	538	547	−6
Methanol	940	907	762	951	4
Octyl alcohol, synthetic	264	254	212	200	4
Phenol, synthetic	244	249	221	222	−2
Phthalic anhydride	284	288	260	249	−1
Propylene	3096	2963	2716	2635	5
Propylene glycol	168	163	141	133	3
Styrene	1238	1122	1022	1089	10
Terephthalic acid	613	590	433	282	4
Toluene	925	861	869	858	7
Toluene diisocyanate	66	61	65	64	8
Xylene	1317	1248	1211	1169	6
Urea	2083	2079	1718	1572	0
INORGANIC CHEMICALS					
Ammonium chloride	753	718	709	703	5
Ammonium sulfate	1883	1929	2048	2104	−2
Calcium carbide	570	555	541	552	3
Calcium superphosphate	568	551	607	535	3
Carbon black	538	489	439	409	10
Chlorine, liquid	729	651	689	666	12
Hydrochloric acid	528	540	616	656	−2
Nitrogen, millions of cu m	4150	3717	3941	3525	12
Oxygen, millions of cu m	7070	6329	6773	7981	12
Sodium carbonate	1355	1162	1179	1085	17
Sodium hydroxide	3021	2777	2870	2906	9
Sodium silicate	714	654	632	623	9
Sulfuric acid	6581	6435	6392	6095	2
Titanium dioxide	185	171	150	156	8
PLASTICS					
Phenolic resins	300	268	246	254	12
Polyethylene	2165	1767	1467	1392	23
Polypropylene	1023	745	608	669	37
Polystyrene	1227	1032	900	876	19
Polyvinyl chloride	1583	1204	1030	1044	31
DYES, synthetic	60	54	54	55	11
RUBBER CHEMICALS, organic	45	41	36	33	10
RUBBER, synthetic	1107	1028	971	941	8

Source: Ministry of International Trade & Industry

COMPANY RESULTS: Most profit margins widen in Japan but still remain low

$ Millions	Sales	Net income	Profit margin	Total assets	Employees (thousands)
Mitsubishi Chemical Industries[a]					
1979	$2486.0	$24.1	1.0%	$2996.4	8.2
1978	2457.8	11.0	0.5	3534.6	8.7
1977	2451.2	22.7	0.9	3319.4	9.0
1976	2133.0	18.1	0.9	2689.3	9.5
Sumitomo Chemical[b]					
1979	$2225.3	$28.1	1.3%	$2016.6	9.9
1978	2078.1	18.6	0.9	2532.3	10.8
1977	2006.8	6.0	0.3	2601.2	11.6
1976	1979.1	12.5	0.6	2331.7	15.5
Asahi Chemical Industry					
1979	$2085.0	$44.1	2.1%	$2265.7	13.8
1978	2029.2	33.9	1.6	2475.9	14.3
1977	1979.9	21.9	1.1	2402.0	15.7
1976	1684.8	16.0	1.0	1971.2	17.3
Toray Industries					
1979	$1864.5	$52.1	2.8%	$2010.5	13.9
1978	1929.3	40.3	2.1	2270.9	14.7
1977	1828.1	4.3	0.0	2117.5	16.9
1976	1491.0	14.6	1.0	1731.0	18.4
Teijin					
1979	$1563.8	$28.1	1.8%	$1815.4	7.2
1978	1610.7	10.7	0.7	2016.2	7.7
1977	1552.9	1.8	0.1	1977.1	8.1
1976	1243.9	9.2	0.7	1524.9	11.8
Mitsui Toatsu Chemicals					
1979	$1563.8	$34.1	2.2%	$1613.2	7.8
1978	1455.5	5.4	0.4	1773.5	8.3
1977	1388.1	(19.7)[c]	—	1761.8	8.9
1976	1086.4	(32.5)[c]	—	1427.8	9.5
Showa Denko[b]					
1979	$1463.5	$24.1	1.7%	$1475.1	4.3
1978	1339.3	17.6	1.3	1850.5	5.2
1977	1672.1	(8.6)[c]	—	2192.0	6.3
1976	1348.4	(8.5)[c]	—	1751.3	7.6
Dainippon Ink & Chemicals					
1979	$1283.1	$18.4	1.4%	$1124.1	5.5
1978	1248.2	19.4	1.6	1083.6	5.5
1977	1080.6	16.7	1.6	979.4	5.5
1976	809.6	12.3	1.5	739.2	5.5
Mitsubishi Petrochemical[b]					
1979	$1327.2	$16.0	1.2%	$1384.4	3.9
1978	1213.0	8.8	0.7	1606.8	4.3
1977	1202.7	3.7	0.3	1586.0	4.5
1976	986.8	7.6	0.8	1255.5	4.6
Sekisui Chemical					
1979	$1182.8	$14.0	1.2%	$1106.7	6.0
1978	1127.9	7.4	0.7	1025.3	5.9
1977	955.1	4.7	0.5	854.6	6.2
1976	688.5	3.2	0.5	644.5	6.0
Mitsui Petrochemical Industries					
1979	$1082.6	$20.1	1.9%	$1127.0	4.8
1978	913.8	11.0	1.2	1220.7	4.8
1977	863.9	7.9	0.9	1185.7	4.7
1976	699.5	13.6	1.9	874.0	4.7
Unitika					
1979	$781.9	$10.8	1.4%	$1024.1	6.5
1978	865.3	12.0	1.4	1245.6	6.8
1977	826.8	(39.7)[c]	—	1295.2	8.3
1976	873.3	(36.1)[c]	—	1071.5	12.5
Kuraray					
1979	$741.8	$6.0	0.8%	$824.4	5.2
1978	789.9	1.0	0.1	919.7	5.4
1977	741.0	(14.4)[c]	—	956.0	6.3
1976	623.9	(2.0)[c]	—	794.7	8.7

$ Millions	Sales	Net income	Profit margin	Total assets	Employees (thousands)
Mitsubishi Rayon					
1979	$673.6	$16.0	2.4%	$703.0	3.4
1978	700.7	(5.1)[c]	—	808.4	3.7
1977	799.8	(6.0)[c]	—	918.8	4.8
1976	693.9	16.9	2.4	785.8	5.4
Kyowa Hakko Kogyo[b]					
1979	$701.7	$12.0	1.7%	$584.7	4.8
1978	692.5	13.1	1.9	658.9	4.8
1977	660.8	11.5	1.7	624.1	4.7
1976	495.6	4.9	1.0	483.3	4.7
Denki Kagaku Kogyo					
1979	$733.8	$16.0	2.2%	$881.0	4.0
1978	691.3	9.6	1.4	942.2	4.1
1977	637.1	6.1	1.0	894.6	4.2
1976	497.6	[illegible]	1.5	643.4	4.3
Toyo Soda Mfg.					
1979	$761.8	$10.0	1.3%	$977.4	4.9
1978	720.5	10.5	1.5	1075.0	5.0
1977	674.3	3.5	0.5	1043.1	5.2
1976	524.9	3.9	0.7	812.5	5.3
Kanegafuchi Chemical Industry					
1979	$641.5	$15.2	2.4%	$466.4	3.0
1978	615.7	7.9	1.3	534.2	3.0
1977	555.5	(2.4)[c]	—	543.7	3.1
1976	438.0	4.3	1.0	459.8	3.2
Mitsubishi Gas Chemical					
1979	$681.6	$13.6	2.0%	$739.8	3.8
1978	604.4	10.9	1.8	823.7	3.8
1977	544.6	8.0	1.5	766.7	3.9
1976	455.5	7.9	1.7	579.7	4.0
Hitachi Chemical					
1979	$581.4	$8.8	1.5%	$335.8	4.1
1978	601.6	6.6	1.1	365.5	4.0
1977	522.5	(2.9)[c]	—	355.8	4.0
1976	407.5	2.9	0.7	276.9	4.1
Tokuyama Soda					
1979	$585.4	$6.0	1.0%	$545.9	2.4
1978	567.8	6.5	1.1	605.8	2.4
1977	523.7	5.3	1.0	592.6	2.4
1976	379.0	2.9	0.8	484.7	2.5
Japan Synthetic Rubber					
1979	$521.3	$9.6	1.8%	$578.7	2.6
1978	514.0	6.6	1.3	594.8	2.7
1977	466.6	4.4	0.9	583.7	2.7
1976	358.0	4.2	1.2	461.9	2.7
Shin-Etsu Chemical[d]					
1979	$481.2	$8.8	1.8%	$418.2	2.2
1978	484.7	7.9	1.6	477.3	2.3
1977	428.9	5.4	1.3	452.7	2.7
1976	343.2	4.7	1.4	346.3	2.8
Nissan Chemical Industry[e]					
1979	$481.2	$3.2	0.7%	$475.8	1.8
1978	483.3	3.1	0.6	553.8	1.8
1977	437.7	1.4	0.3	519.5	2.2
1976	333.3	1.8	0.5	409.6	2.2
Daicel Chemical					
1979	$481.2	$14.8	3.1%	$467.4	3.1
1978	467.0	8.6	1.8	461.5	3.4
1977	453.2	6.5	1.4	425.3	3.4
1976	356.1	5.2	1.5	334.2	3.5
Nippon Zeon					
1979	$433.0	$3.6	0.8%	$477.6	2.8
1978	449.2	3.5	0.8	497.9	2.9
1977	412.1	1.0	0.2	466.1	2.9
1976	318.3	2.1	0.7	377.9	3.0

a Fiscal year starts Jan. 31. **b** Fiscal year starts Dec. 31. **c** Deficit. **d** Fiscal year starts May 31. **e** Fiscal year starts April 30. **Note:** Fiscal years starting March 31 of each year unless otherwise specified. Fiscal year 1979 are estimates based on results for the first three quarters.

Results were converted from yen on the following basis: fiscal year 1979—$1.00 = 249.4 Y; fiscal year 1978—$1.00 = 209.3 Y; fiscal year 1977—$1.00 = 222.9 Y; fiscal year 1976—$1.00 = 281.0 Y. **Source:** Toyo Keizai Shinposha

CANADA SECTION 6 FOREIGN CHEMICAL INDUSTRIES

Canada's big investment in petrochemicals has started to pay off. Production of such key chemicals as benzene and ethylene, and of major plastics, has more than doubled in the past five years, with gains of 20 to 30% in 1979 alone. But ammonia and urea, after several strong years, showed no growth at all in 1979. Except for phosphoric acid, other high-tonnage items had only modest gains. So despite some glittering exceptions, the overall index of production of chemicals and chemical products increased only slightly in 1979.

Still, most Canadian chemical companies could boast of improved profitability in 1979, thanks to firming prices and booming exports. With big new plants and with relatively low-price feedstocks, Canada's petrochemical producers recently have become a competitive force in world markets. Chemical exports rose 41% from 1978 levels. Chemical imports went up too, but only 23%. Consequently, Canada was, for a change, a net exporter of chemicals in 1979.

TRADE BALANCE: In the black, both overall . . .

$ Millions (Canadian)	1979	1978	1977	1976
Exports[a,b]	$65,327	$52,842	$44,554	$38,475
Imports[c]	62,453	49,938	42,332	37,494
Trade balance	2,874	2,904	2,222	981

. . . and with chemicals, too, for a change

$ Millions (Canadian)	1979	1978	1977	1976
Chemical exports[b,d]	$3,315	$2,357	$1,739	$1,383
Chemical imports[c]	3,213	2,621	1,992	1,682
Chemical trade balance	102	−264	−253	−299

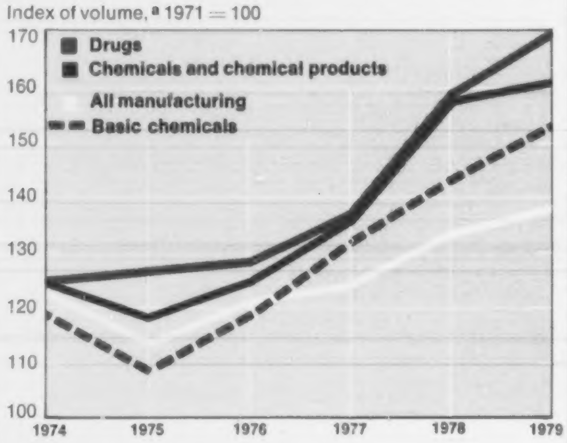
a Includes re-exports. b Values as declared on export documents; may include shipping costs. c Values as established for duty purposes. d Domestic exports only. **Source:** Statistics Canada

COMPANY RESULTS: Profit margins widen

$ Millions (Canadian)[a]	Sales	Net income[b]	Profit margin	Capital expenditures	Employees (thousands)
C-I-L INC.[c]					
1979	$880.0	$36.3	4.1%	$84.4	8.0
1978	746.9	26.4	3.5	97.5	8.0
1977	667.8	24.9	3.7	58.5	8.3
1976	613.9	24.4	4.0	62.1	9.0
CELANESE CANADA					
1979	$353.6	$21.2	6.0%	$24.4	4.4
1978	290.7	7.4	2.4	18.2	4.6
1977	254.7	1.1	0.4	5.7	4.7
1976	216.1	(10.3)[d]	—	20.7	4.7
DOW CHEMICAL CANADA[e]					
1979	$629.7	$50[f]	7.9%[f]	$292	3.8
1978	438.5	27.6[f]	6.3[f]	250.4	3.3
1977	396.4	46.0[f]	11.6[f]	210.3	3.0
1976	369.8	65.9[f]	17.8[f]	87.6	2.8
DU PONT CANADA					
1979	$879.6	$58.9	6.7%	$23.3	5.6
1978	661.9	10.2	1.5	10.7	5.4
1977	537.6	7.6	1.4	16.7	5.5
1976	458.8	(2.1)[d]	—	65.8	5.7
UNION CARBIDE CANADA					
1979	$685.9	$57.8	8.4%	$30.1	4.8
1978	528.2	20.1	3.8	46.3	4.7
1977	406.5	20.5	5.0	82.3	4.7
1976	393.7	29.4	7.5	110.2	4.8

a Unless otherwise indicated. b Excluding extraordinary gains and losses. c Name changed from Canadian Industries Ltd. on Jan. 1, 1980. d Deficit. e Amounts in U.S. dollars. f Profits before taxes.

Drugs, basic chemicals show good growth



a Real domestic product. **Source:** Statistics Canada

PRODUCTION: Ammonia hits a plateau

Thousands of tons unless otherwise noted	1979	1978	1977	1976	Change 1978–79
Ammonia, anhydrous	2657.2	2642.9	2383.0	1530.5	0%
Ammonium nitrate	1002.8	959.9	1019.4	1026.0	4
Ammonium phosphate	1481.6	1299.5	1264.7	1069.4	14
Benzene[a]	4479.4	3491.3	2741.1	2590.9	28
Caustic soda, 100% NaOH	1256.3	1142.2	1117.5	1016.4	10
Chlorine	1140.1	1037.0	979.2	990.2	10
Ethylene	1183.9	910.2	625.3	560.9	30
Hydrochloric acid,	169.9	170.4	150.2	120.7	0
Phosphoric acid, 100% P_2O_5	807.6	610.5	612.5	576.0	32
Polyesters, unsaturated[b]	59.9	44.7	46.1	40.5	34
Polyethylene[b]	1303.0	1052.7	760.7	663.4	24
Polystyrene[b]	263.8	217.7	199.5	167.4	21
Polyvinyl chloride[b]	336.0	275.0	219.8	213.3	22
Sodium chlorate	256.6	219.5	178.1	152.2	17
Sulfuric acid, 100%	4063.0	3594.5	3461.6	3133.2	13
Urea	1335.6	1341.7	887.0	383.0	0

a Thousands of bbl. b Millions of lb. **Source:** Statistics Canada

SHIPMENTS: Chemicals continue to show above-average growth in Canada

$ Millions (Canadian)	Shipments, monthly average 1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	Annual change 1978–79	1969–79
All manufacturing	$12,520.7	$10,743.7	$9070.6	$8190.4	$7371.6	$6871.2	$5563.1	$4687.2	$4189.5	$3865.2	16.5%	12.6%
Chemicals and chemical products	791.9	663.3	535.6	475.3	425.6	383.9	291.9	246.2	231.8	218.3	19.4	13.9
Petroleum and coal products	1,003.0	837.9	711.0	576.8	496.1	432.1	256.1	203.4	176.2	151.6	19.7	21.5
Rubber and plastics products	300.3	250.1	211.0	192.7	162.9	152.8	131.4	109.7	97.0	89.4	20.1	13.0
Paper and allied products	1,032.0	839.5	744.8	685.7	594.2	639.7	439.2	367.8	333.4	327.6	12.7	12.4

Source: Statistics Canada

PRICES: Chemicals up 13.5% with plastics and fertilizers setting the pace

Industry selling price indexes, 1971 = 100	Annual average 1979	1978	1977	1976	1975	1974	1973	1972	Annual change 1978–79	1974–79
All manufacturing industries	217.8	190.4	174.3	161.6	153.7	138.1	116.1	104.4	14.4%	9.5%
Chemicals and chemical products	214.8	189.3	175.9	167.2	160.3	137.1	106.5	101.4	13.5	9.4
Industrial chemicals—inorganic	234.1	204.1	188.4	179.7	169.5	133.5	107.7	102.5	14.7	11.9
Acetylene, compressed	213.2	191.2	170.7	163.7	150.6	116.2	102.9	102.0	11.5	12.9
Caustic soda	240.1	221.4	210.7	195.7	169.5	120.2	107.0	103.3	8.4	14.8
Chlorine	207.9	189.2	180.5	163.3	144.4	114.1	104.3	102.2	9.9	12.7
Oxygen, gas and liquid	191.8	174.6	156.8	152.1	136.0	121.2	108.3	102.6	9.9	9.6
Industrial chemicals—organic	289.0	249.8	228.1	214.2	201.2	170.0	107.8	101.6	15.7	11.2
Plastics and synthetic resins	239.7	206.4	193.3	187.4	181.6	156.0	104.2	100.1	16.1	9.0
Alkyd	158.4	137.5	129.4	131.4	135.1	134.8	109.4	101.1	15.2	3.3
Phenol formaldehyde	300.9	233.6	232.1	235.6	240.9	214.1	111.4	98.2	28.8	7.0
Polyethylene	268.9	223.2	220.3	221.6	213.2	166.3	103.2	98.8	20.5	10.1
Fertilizers, mixed	229.1	191.0	180.2	176.9	204.0	167.5	117.2	102.5	19.9	6.5
Drugs	153.1	140.4	131.4	127.0	121.1	109.9	103.5	100.0	9.0	6.9
Paint and varnish	202.3	183.0	172.8	161.9	153.9	131.9	108.2	101.7	10.5	8.9
Pigments and dry colors	219.6	189.7	175.3	164.9	153.4	136.0	103.7	96.6	15.8	10.1
Soaps and cleansing compounds	169.5	151.2	141.1	134.5	132.1	118.0	105.3	101.2	12.1	7.5

Source: Statistics Canada

EMPLOYMENT: Chemical workers' pay rises 10%

	Employment index (1961 = 100) 1979	1978	1977	1976	Average hourly earnings 1979	1978	1977	1976	Annual change 1978–79	1976–79
All manufacturing	131.5	127.6	126.3	128.1	$ 7.44	$6.84	$6.38	$5.76	8.8%	8.9%
Chemicals and chemical products	132.4	129.7	128.8	127.0	7.67	6.97	6.51	5.89	10.0	9.2
Petroleum and coal products	133.6	128.9	120.0	114.9	10.04	9.26	8.60	7.63	8.4	9.6
Rubber	130.3	124.1	127.5	125.9	7.38	6.61	6.11	5.64	11.6	9.4
Paper and allied products	130.9	129.5	128.8	128.3	8.93	8.24	7.69	6.89	7.2	9.0

Source: Statistics Canada

CHEMICAL IMPORTS: Organics lead

$ Millions (Canadian)[a]	1979	1978	1977	Change 1978–79
Inorganic chemicals	$351.6	$282.3	$236.0	25%
Organic chemicals	887.5	682.0	493.6	30
Fertilizers and fertilizer materials	136.0	94.6	67.6	44
Synthetic and reclaimed rubbers	118.2	93.9	82.0	26
Plastics materials, not shaped	554.8	483.7	376.0	15
Plastic film and sheet	181.1	152.9	124.8	18
Other plastics basic shapes and forms	134.2	110.9	80.3	21
Dyes, except dyeing intermediates	81.6	76.2	52.3	7
Pigments, lakes, and toners	61.8	49.0	34.2	26
Paints and related products	94.9	82.8	64.3	15
Other chemical products	611.2	512.5	381.2	19
TOTAL	**$3212.8**	**$2620.9**	**$1992.4**	**23%**

a Values as established for duty purposes. **Source:** Statistics Canada

CHEMICAL EXPORTS: Organics soar

$ Millions (Canadian)[a]	1979	1978	1977	Change 1978–79
Chemical elements	$146.0	$124.8	$110.7	17%
Other inorganic chemicals	839.5	653.6	352.5	28
Organic chemicals	702.5	401.5	301.4	75
Fertilizers and fertilizer materials	983.8	734.9	659.0	34
Synthetic rubber and plastic materials	366.9	261.6	173.1	40
Plastics basic shapes and forms	119.2	84.0	73.2	42
Other chemical products	157.3	96.3	69.0	63
TOTAL	**$3315.2**	**$2356.7**	**$1738.9**	**41%**

a Domestic exports only. Values as declared on export documents; may include shipping costs. **Source:** Statistics Canada

EASTERN EUROPE
SECTION 6

FOREIGN CHEMICAL INDUSTRIES

Economic growth and industrial development in Eastern Europe, including the chemical industry, slowed in 1979 and fell short of planned targets. In the Soviet Union, for example, industrial output rose only 3.4% and chemical and rubber output 3.0%—both the lowest annual increases since World War II.

Production was below or just equal to 1978 levels for those Soviet chemical sectors for which numbers have been released, including plastics and resins, synthetic fibers, pesticides, and fertilizers. Mineral fertilizer production actually dropped (94.5 million metric tons, compared to 98.0 million in 1978 and 96.8 million in 1977).

Growth was much slower, also, in other East European chemical industries, as they grappled with serious problems in energy, fuel, and raw material supplies, productivity, construction, transportation, and labor shortages. Romania's chemical output, for instance, grew only 1%, compared to 10.6% in 1978 and a target of 18.3%.

PRODUCTION: U.S.S.R. largest Eastern European producer by far

Thousands of tons	1979	1978	1977	1976	1975
U.S.S.R.					
Sulfuric acid	na	24,692	23,263	22,063	20,533
Mineral fertilizers[a,b]	na	26,061	25,897	24,901	24,238
Nitrogen[a,b]	na	10,141	10,046	9,490	9,408
Phosphate[a,c]	na	6,708	6,640	6,243	6,075
Potassium[a,b]	na	9,204	9,201	9,160	8,757
Synthetic ammonia[d]	na	12,456	11,843	11,122	10,878
Plastics[e]	3858	3,877	3,648	3,371	3,133
Sodium hydroxide	na	3,047	2,930	2,870	2,640
Synthetic rubber[f]	na	1,979	1,874	1,731	1,598
Pesticides	524	542	537	503	483
EAST GERMANY					
Sulfuric acid	na	1,071	1,022	1,055	1,105
Mineral fertilizers[a]	na	5,075	4,927	4,816	4,393
Nitrogen[a]	na	976	924	855	593
Phosphate[a,c]	na	455	444	466	471
Potassium[a]	na	3,644	3,559	3,484	3,328
Synthetic ammonia[d]	na	1,315	1,246	1,233	1,013
Plastics	na	830	809	748	667
Sodium hydroxide	na	457	466	486	487
Synthetic rubber	na	171	162	160	159
POLAND					
Sulfuric acid	na	3,653	3,602	3,504	3,762
Mineral fertilizers[a]	na	2,889	2,877	2,858	2,845
Nitrogen[a]	na	1,621	1,677	1,706	1,690
Phosphate[a]	na	1,131	1,065	1,023	1,024
Synthetic ammonia[d]	na	1,775	1,835	1,903	1,882
Plastics	na	519	510	492	464
Sodium hydroxide	na	510	485	428	431
Synthetic rubber	na	139	131	129	119
ROMANIA					
Sulfuric acid	na	1,785	1,679	1,714	1,596
Mineral fertilizers[a]	na	2,713	2,184	2,060	1,906
Nitrogen[a]	na	1,890	1,522	1,467	1,424
Phosphate[a]	na	752	604	543	445
Synthetic ammonia[d]	na	2,455	1,976	1,830	1,719
Plastics	na	608	599	513	383
Sodium hydroxide	na	882	810	742	624
Synthetic rubber	na	162	150	105	109

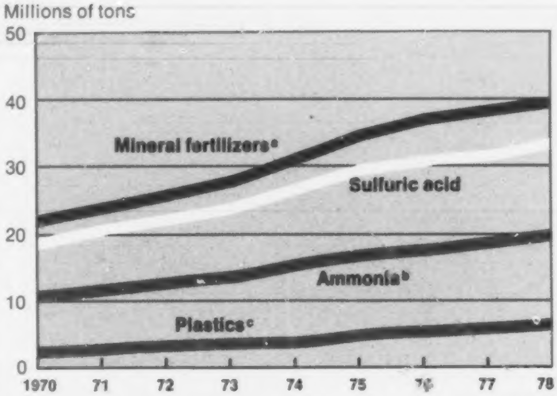
a As N, P_2O_5, or K_2O. **b** Including some product used for technical purposes. **c** Including production of ground phosphate rock for direct applications and phosphate animal feeds. **d** Nitrogen content. **e** Including resins for man-made fibers. **f** Estimated. **na** = not available. **Sources:** Central Intelligence Agency, Department of Commerce

PRODUCTION GROWTH: Slower last year

% annual change in gross output	Plan 1979	1979	1978	1977	1976
Bulgaria					
All industry	7.8%	6.5%	6.9%	6.8%	6.8%
Chemicals and rubber	9.1	8.9	10.0	12.4	4.9
Czechoslovakia					
All industry	4.5	3.7	4.8	5.7	5.5
Chemicals and rubber	na	2.9	5.9	6.7	9.0
East Germany					
All industry[a]	5.5	4.8	5.4	5.4	5.9
Chemicals and rubber[a]	5.8	4.6	9.2	4.4	7.0
Hungary					
All industry	4.0	2.8	4.9	6.6	4.6
Chemicals and rubber	6.4	4.6	10.7	6.9	10.8
Poland					
All industry	4.9	2.8[b]	4.9	6.6	9.3
Chemicals and rubber	7.8	na	3.9	4.4	10.8
Romania					
All industry	11.3	8.0	9.6	12.5	11.4
Chemicals and rubber	18.3	1.0	10.6	13.9	16.1
U.S.S.R.[c]					
All industry	5.7	3.4	4.8	5.7	4.8
Chemicals and rubber	9.0	3.0	6.0	6.5	7.9

a Industrial commodity production. **b** Sales. **c** Figures based on Soviet official statistics; Central Intelligence Agency estimates are lower because of postulated upward bias in official figures. **na** = not available. **Sources:** United Nations Economic Commission for Europe (based on official national statistics), Department of Commerce, Department of State

Output of chemicals in Eastern Europe has doubled since 1970



a As N, P_2O_5, and K_2O. **b** Nitrogen content. **c** Including resins for man-made fibers in U.S.S.R. **Note:** Data for U.S.S.R., Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania. **Source:** Central Intelligence Agency

MAN-MADE FIBERS: U.S.S.R. makes more than half of East Europe's total output

Millions of lb	1979	1978	1977	1976	Change 1978–79
NONCELLULOSIC FIBERS					
Bulgaria	na	99	92	92	na
Czechoslovakia	165	163	152	165	1%
East Germany	na	281	273	268	na
Hungary	42	43	37	26	−2
Poland	323	335	323	293	−3
Romania	na	257	251	235	na
U.S.S.R.	na	1045	1003	880	na

na = not available. **Source:** Comité International de la Rayonne et des Fibres Synthétiques

Millions of lb	1979	1978	1977	1976	Change 1978–79
CELLULOSIC FIBERS					
Bulgaria	na	73	68	73	na
Czechoslovakia	125	156	160	160	−20
East Germany	na	359	372	374	na
Hungary	20	20	20	20	0
Poland	185	206	211	209	−10
Romania	na	138	132	139	na
U.S.S.R.	na	1397	1364	1346	na
TOTAL	—	**4572**	**4458**	**4280**	—

SOVIET FOREIGN TRADE: Growing deficit in chemicals

$ Millions	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970
Exports[a]	64,913	52,432	45,209	37,269	33,401	27,374	21,332	15,409	13,792	12,787
Imports[a]	57,961	50,798	40,914	38,212	37,070	24,861	20,980	16,104	12,467	11,720
Trade balance	6,952	1,634	4,295	−943	−3,669	2,513	352	−695	1,325	1,067
Chemical exports[a]	na	1,284	1,063	939	1,027	887	549	439	396	364
Chemical imports[a]	na	2,188	1,850	1,668	1,747	1,448	954	868	702	618
Chemical trade balance	na	−904	−787	−729	−720	−561	−405	−429	−306	−254

a F.o.b. **na** = not available. **Source:** Central Intelligence Agency

CHINA SECTION 6

FOREIGN CHEMICAL INDUSTRIES

The People's Republic of China racked up strong increases in chemical production in 1979, led by a 23% rise in production of chemical fertilizer. On a nutrient content basis, 820,000 metric tons of new fertilizer capacity came on stream, as did 83,000 metric tons of synthetic fiber capacity. New capacity for ammonia, fibers, and tires failed to produce enough to meet planned targets, however.

Last year was the first of three in China's economic "readjustment" policy, involving slower and more selective development before the more rapid growth planned under the next five-year plan (1981–85). But capital construction programs remain overextended and further cutbacks are likely.

PRODUCTION: Fertilizers are important

Thousands of metric tons, unless otherwise noted	1979	1978	1977	1976	Change 1978–79
Synthetic ammonia[a]	na	6749	5619	4068	na
Chemical fertilizer[b]	10,654	8693	7238	5240	23%
Nitrogen (N)	8,821	7637	na	na	16
Phosphate (P_2O_5)	1,817	1033	na	na	76
Potassium (K_2O)	16	21	na	na	−24
Sulfuric acid	7,000	6610	5375	na	6
Sodium hydroxide	1,826	1640	1386	na	11
Sodium carbonate	1,486	1329	1077	na	12
Calcium carbide	1,407	1237	na	na	14
Plastics	793	679	524	na	17
Insecticides	537	533	457	na	1
Ethylene	435	380	303	na	14
Synthetic detergents	397	324	257	na	22
Synthetic fibers	326	285	190	na	14
Pharmaceuticals	42	41	35	na	2
Rubber tires (thousands of units)	11,690	9359	na	na	25

a Nitrogen content basis, including only ammonia produced for fertilizer. b Nutrient content basis. **na** = not available. **Sources:** State Statistical Bureau of the People's Republic of China, Central Intelligence Agency

FOREIGN TRADE: Trade deficit widens. . .

$ Millions[a]	1979[b]	1978	1977	1976
Exports[c]	13,000	9,895	8085	7265
Imports[d]	14,700	10,315[c]	6615[c]	6010
Trade balance	−1,700	−420	1470	1255

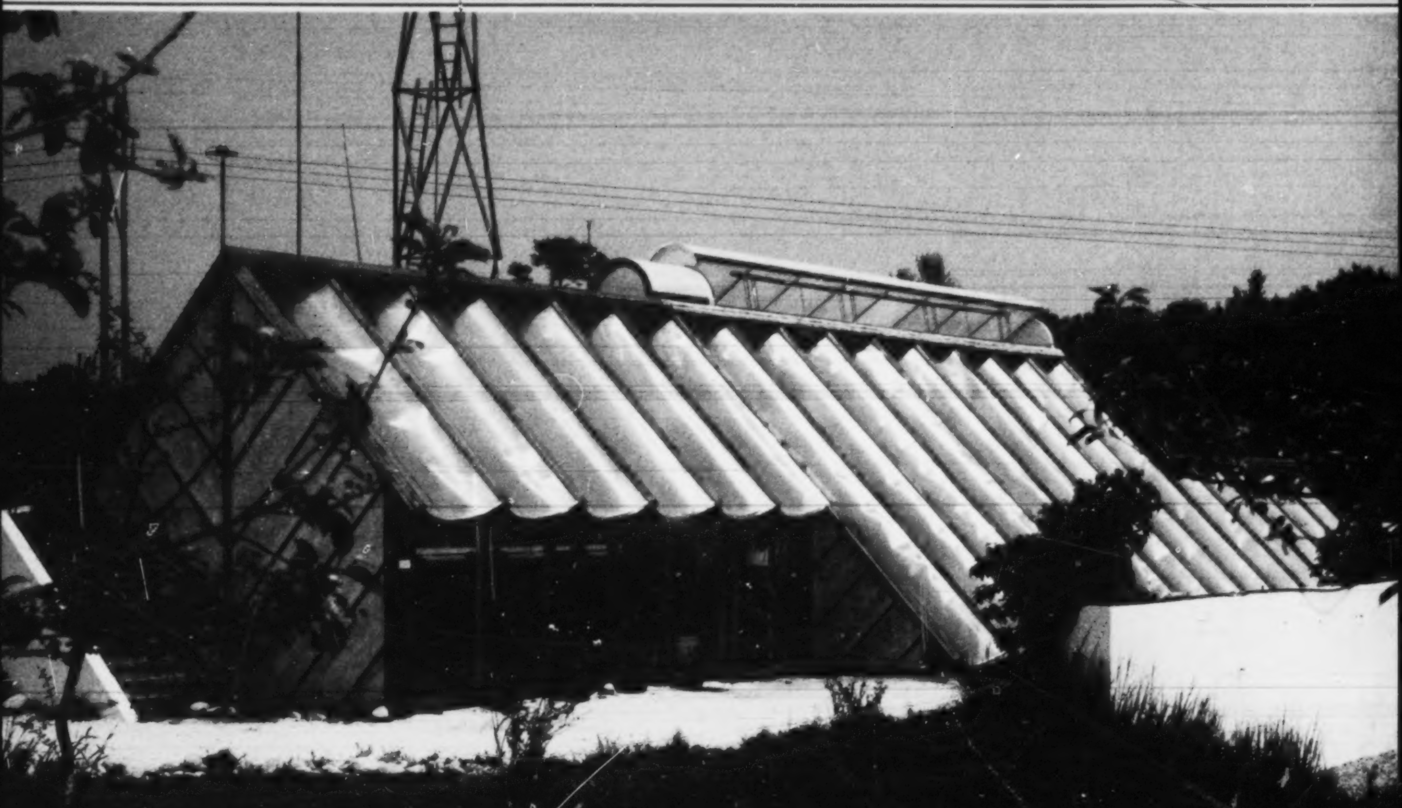
. . .with chemicals accounting for bigger share

$ Millions	1979[b]	1978	1977	1976
Chemical exports[c]	na	465	410	330
Medicinal products	na	75	60	40
Essential oils and soap	na	55	60	45
Chemical imports[d]	na	1,125[c]	835[c]	600
Fertilizers[e]	na	410[c]	320[c]	230
Elements and compounds	na	340[c]	270[c]	210
Plastic materials	na	130[c]	90[c]	90
Dyeing materials	na	60[c]	40[c]	20
Chemical trade balance	na	−660	−425	−270

a Numbers rounded to nearest $5 million and are estimates based on data reported by China's trading partners. b Preliminary estimate. c F.o.b. d CIF, unless otherwise noted. e Manufactured, excluding phosphate rock, ammonium chloride, sodium nitrate, and potassium nitrate. **na** = not available. **Source:** Central Intelligence Agency

Monomers feel decline in fibers market
A Key Chemicals Review Page 11

NEWS



Appropriate technology
challenges science policy
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Chemical & Engineering NEWS

Cover: The "Ark" at New Alchemy Institute near Woods Hole, Mass. A model for appropriate technology, it contains areas for growing vegetables and for producing heating through aquaculture. Photo by C&EN's Wil Lepkowski

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Major fiber monomers face slump in 1980

Production declines forecast for cyclohexane, dimethyl terephthalate, and ethylene oxide as major recession cuts into fiber demand

Starting materials for the two largest-volume U.S. synthetic fibers now appear to be facing a repeat this year of the 1975 recession. Production of dimethyl terephthalate (DMT), purified terephthalic acid (PTA), ethylene oxide, and cyclohexane has begun to slump as the recession intensifies.

Although opinion in the industry varies, consensus is that all of these chemicals will have lower production in 1980 than they had in 1979. The size of the drop will vary depending on markets. Current estimates place the declines on the order of 5 to 10%, but almost everybody qualifies their estimates with a proviso to wait to see how bad the recession becomes.

If the 1975 recession pattern is followed closely, developments in 1980 will differ a bit from current forecasts. In 1975, combined production of DMT and PTA still rose 1%, production of ethylene oxide increased 4%, and cyclohexane output sank 26%.

However, many forecasters now expect 1980 DMT/PTA production to fall below 1979 for the first substantial dip in its history. This forecast assumes that polyester fibers will post a production decline, something they did not do in the previous recession. It also assumes that nonfiber markets for polyester will not grow fast enough to make up for declines of DMT/PTA going to fibers.

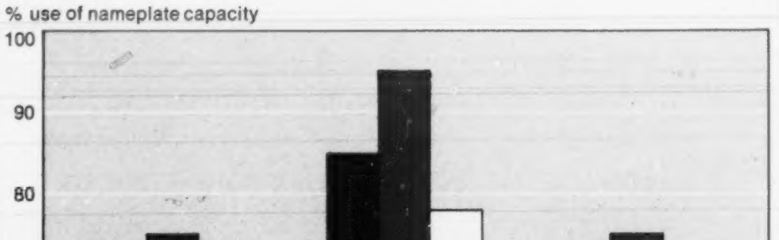
By contrast, fibers have less impact on ethylene oxide than on any of the other chemicals; only about 30% of ethylene oxide production goes to polyesters.

In the mid-1970's production of ethylene oxide eventually fell, 4% in 1976, a year later than the decline in most other chemicals. Nonfiber uses of ethylene oxide, particularly antifreeze, apparently were responsible for the drop, since polyesters grew 2% in 1976.

A runup in antifreeze inventories seems to have caused the delayed decline in ethylene oxide production in 1976. Unfortunately, a similar situation may be occurring now.

Antifreeze had a better year in 1979 than many in the industry expected. These sources conclude that inventories are up abnormally and will have to be worked off in 1980. Since about 30% of ethylene oxide production eventually ends up as antifreeze, a 10% decline in antifreeze production expected in 1980 will translate back to ethylene oxide as about a 3% drag against production.

Plant use in fiber monomers will drop this year



Sources: Producers and C&EN estimates, International Trade Commission

Cyclohexane and nylon were both hit harder and longer by the 1974–75 recession than were DMT/PTA, ethylene oxide, and polyesters. Nylon fiber production didn't get above its pre-1975 peak until 1977, and cyclohexane not until 1979.

The reason for the slower recovery for cyclohexane was a partial shift out of cyclohexane to butadiene as a raw material for the nylon intermediate, hexamethylenediamine. Other influences, such as slack export markets, also apparently slowed cyclohexane's recovery.

All of the fiber materials are forecast for declining exports in 1980. Cyclohexane has the largest export stake, relatively important at about a sixth of production. Exports take only 4% of DMT/PTA production. Exports of ethylene oxide are very small, although exports of derivatives are sizable. Hence, cyclohexane has the most to lose in an export slump.

Exports of downstream fibers could decline relatively more than exports of the starting materials after a booming two years. The main reasons are a spreading business slowdown in Western Europe and efforts in Europe to build trade barriers to U.S. fibers imports.

Unhappily, this year profits haven't much of a chance against a combination of the export problem, lower U.S demand, and a rise in some plant capacity. The result will be a notable drop in capacity use with an attending drop in cost efficiencies.

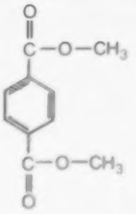
Already, producers of fiber materials are getting downward price pressure. The source is price weakness in upstream raw materials for these chemicals. For example, prices of benzene for cyclohexane are dropping, about 15 cents a gal from $1.80 so far. And prices of *p*-xylene for DMT/PTA are weakening as competing gasoline demand slumps, lowering mixed xylene prices. Ethylene for ethylene oxide has lost at least 0.5 cent of its April price increase of 3.5 cents to about 24.5 cents a lb.

For details of the immediate 12-month outlook for the starting material chemicals, see the following pages.

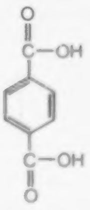
Bruce Greek, Houston

Key Chemicals

DMT/PTA



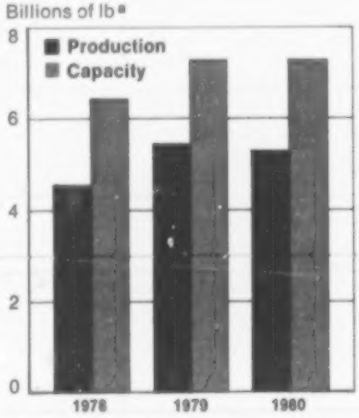
DMT



PTA

- ***Demand declining***
- ***Capacity flat***
- ***Prices softening***

PRODUCTION/CAPACITY



[a] Total for both DMT and PTA.

HOW MADE

For PTA, oxidation of p*-xylene; for DMT, oxidation and concurrent esterification with methanol*

MAJOR DERIVATIVES

Polyethylene terephthalate almost 100%

MAJOR END USES

Polyester, 95%

FOREIGN TRADE

Exports—Falling in 1980 to 325 million lb, imports—negligible

PRICES

31 cents per lb, DMT; 33 cents per lb, PTA

COMMERCIAL VALUE

$1.4 billion for total production, 1979; $1.7 billion, 1980

After enjoying a very sunny 1979, U.S. producers of dimethyl terephthalate (DMT) and purified terephthalic acid (PTA) are facing a darker 1980. Production of DMT and PTA in 1979 rose nearly 20% to about 5.5 billion lb. This year, production will be off at least 5% to about 5.3 billion lb.

The radical change in the production growth rate, first noticed in late 1979, fits the traditional pattern for a fibers-related business. DMT and PTA production, nearly all of which goes into polyester, rises and falls quickly over short periods with cyclical moves in fibers. As yet, nonfiber uses of polyester are not large enough to dampen fibers' influence on the monomers. This year, falling polyester fiber shipments bode ill for DMT/PTA.

Given the decline in DMT/PTA production expected during 1980, producers must look to the future for new overall growth. When demand picks up again, plant capacity looks sufficient for a while, even though no new major capacity came on stream during 1979 or will in 1980.

Of course, a couple of years of renewed 10% growth in demand will pretty well eat up the current 25% surplus in capacity. Combined nameplate capacity for DMT and PTA is about 7.3 billion lb per year.

Almost all DMT/PTA goes to make polyethylene terephthalate (PET). Another, but minor, polymer product made from DMT/PTA is polybutylene terephthalate (PBT), using 1,4-butanediol in place of ethylene glycol as the other starting material. PBT, an engineering resin, has had some acceptance problems in potential uses. As a result, its growth rate is large, but not spectacular, from a very small base.

Fibers will consume a bit under 80% of DMT/PTA production in 1980. Apparel dominates these fiber uses with about 60% of the total. Most apparel fabrics are blends with natural fibers such as cotton and wool. However, producers hope that 100% polyester garments will return to favor as improvements are made in the fabrics, notably through use of smaller-sized polyester yarn.

Of the nonfiber uses of DMT/PTA, a bit under 8% will go into films in 1980; an almost equal share will go to containers, mainly soft drink bottles; small quantities will go to specialty chemicals used as intermediates; and the remainder will be exported. Exports are expected to decline as the world economy falters and U.S. producers' costs rise closer to those outside.

In the U.S., film use continues to grow well. However, the growth rate in terms of DMT/PTA consumption will be in the 5 to 6% range in 1980, down from 8 to 10% earlier.

Among specific film uses, photographic films of various types continue to take about 40% of the total. The next largest use, growing faster, is various kinds of magnetic tapes. Most rapidly growing of all film uses is videotape, rising from a small base.

Still, the big jump in DMT/PTA consumption in 1980 will be in containers. Some optimists call for a nearly 50% annual climb in polymer volume from about 235 million lb of PET in 1979 to around 350 million lb in 1980. Hence, containers will keep 1980 from being a rougher year for DMT/PTA than fibers use alone would indicate.

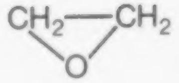
Several factors are spurring the container boom. The most important is promotional work by producers of soft drinks. Other significant factors are increased capacity to make plastic bottles and other containers, and marketing efforts of DMT/PTA producers.

The PET bottle market is not without problems. For one, glass container manufacturers are fighting back with competitive pricing in spite of rising energy costs. For another, most of the volume of plastic bottles is confined to large-size soft drink containers because the cost advantage of glass is less for large sizes. Finally, recycling could become a problem, but experiments have begun to recycle PET bottles into insulating-type fibers.

Depending on promotional campaigns and on adaptation of PET to smaller-size bottles, the market for these bottles could continue to grow at high rates. The resulting increase in demand for DMT/PTA would be between 100 million and 150 million lb annually for the next three years.

For DMT/PTA, then, some newer consumer products will make 1980 a slightly better year than it would be if fibers had full market control.

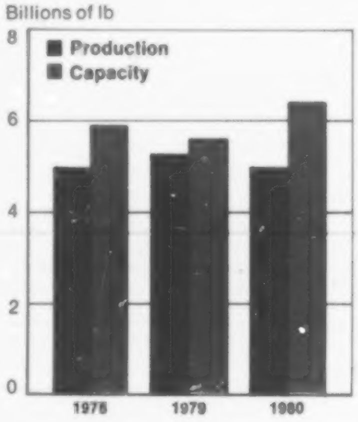
Key Chemicals



Ethylene Oxide

- ***Demand slowing***
- ***Capacity rising***
- ***Prices weakening***

PRODUCTION/CAPACITY



HOW MADE

Vapor-phase catalytic oxidation of ethylene using oxygen or air

MAJOR DERIVATIVES

Ethylene glycol 60%, ethoxylates 10%, glycol ethers 10%

MAJOR END USES

Antifreeze 30%, polyester 30%, surfactants 10%, solvents 5%

FOREIGN TRADE

Exports and imports very small; derivatives traded in larger volumes

PRICES

40 cents per lb, contract, in bulk; spot market very small

COMMERCIAL VALUE

$1.7 billion for total production, 1979; $2.0 billion, 1980

U.S. ethylene oxide producers could be facing a more difficult year in 1980 than might at first be indicated.

Production probably will be down only a small amount—possibly as little as 6%—to about the 1978 level of 5 billion lb from 5.3 billion lb in 1979. Such a decline would be less than that expected for many of the final products from ethylene oxide and its derivatives.

However, plant capacity for ethylene oxide is rising and is set to continue rising in 1980 and beyond. As 1980 opened, U.S. capacity was up nearly 15% from a year ago to about 6.4 billion lb. More capacity is on the way as producers complete expansions and debottlenecking.

Hence in 1980, ethylene oxide capacity will be run well below levels of recent years. If demand is enough to hold production at 5 billion lb, nameplate capacity use will be a bit less than 80%. In contrast, capacity use ran about 93% during 1979.

Periodically last year some derivatives of ethylene oxide, especially the glycol, became tight. One large unit at Calcasieu Chemical was shut down for most of the year. In addition, inventories were held down in anticipation that Oxirane's big new ethylene glycol plant would begin operations. As time went on and production from the new plant failed to meet industry expectations, a scramble for other supplies developed.

The glycol outlook is now completely changed. 1980 will not be a good year for the derivative, which takes about 60% of oxide production. All but a small part of ethylene glycol's U.S. consumption goes to two uses—antifreeze and polyester materials. Both these uses probably will decline more than 6% from 1979. Because ethylene glycol is just part of the total weight of these end products, the glycol volume involved will not be so great as for the end products but still will be substantial.

Antifreeze soon may lose its position as the largest single use of ethylene oxide. If antifreeze demand falls more than anticipated in 1980, polyester finally could pass it as the leading outlet.

In 1979, antifreeze sales increased about 4% from 1978, about twice as fast as the long-term forecast. But now that automobile sales are falling badly in the first half of 1980, original-fill antifreeze sales will decline more than might be expected from just the shift to smaller cars and smaller cooling systems.

In addition to the resulting decline of 5 million gal or so in original-fill antifreeze sales this year, unfavorable economic conditions will reduce replacement sales. One pessimistic forecaster believes that overall antifreeze sales will drop nearly 10% in 1980 to about 205 million gal. Such a drop could translate to a nearly 5% decline in ethylene oxide production.

If this weren't enough, poorer fortunes for polyesters in 1980 also would hurt ethylene oxide, but to a lesser degree. Ethylene oxide accounts for 10% of the weight of polyethylene terephthalate. As a result, a 5 to 10% polyester production decline in 1980 would have a minor effect on demand for ethylene oxide.

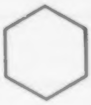
Other uses of ethylene oxide are varied and mostly small compared to glycol. One use, cyclic and acyclic ethoxylates, accounts for most of the actual merchant sales of ethylene oxide, although only a bit more than 10% of oxide production. Most of the rest of ethylene oxide is converted to derivatives by producers at the same site, and enters commerce in those forms.

Other products made from ethylene oxide, such as the di- and triglycols, polyethylene glycol, ethanolamines, and many others, will have varying fortunes during 1980. None of these consume ethylene oxide in large enough volume to have significant impact on total oxide production in the event of a major shift in demand.

The smaller products with a potential upturn this year are the glycols and amines used in processing natural gas to remove water and acid gases. Changes in composition of natural gas as newer wells replace older wells and changes in processing technology are slowly causing an increase in use of these processing chemicals.

On balance, 1980 will be a downward blip in the growth curve for ethylene oxide. Producers have experienced such breaks before in oxide's slow growth trend, so won't be surprised by the accompanying pause in profitability growth.

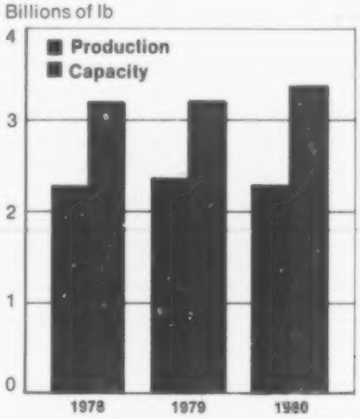
Key Chemicals



Cyclohexane

- ***Market soft***
- ***Capacity up a bit***
- ***Prices falling***

PRODUCTION/CAPACITY



HOW MADE

Catalytic hydrogenation of benzene; recovery from natural gas condensates

MAJOR DERIVATIVES

Adipic acid 65%, caprolactam 30%

MAJOR END USES

Nylon 66, 60%; nylon 6, 30%

FOREIGN TRADE

Exports—declining about 10% this year to about 400 million lb, imports—negligible

PRICES

$1.72 per gal, contract, in bulk; spot market tiny

COMMERCIAL VALUE

$500 million for total production, 1979; $600 million, 1980

U.S. producers of cyclohexane will have a more difficult year in 1980 than in 1979, like producers of almost all other large-volume organic chemicals.

Production of cyclohexane in 1980 could turn out to be less than the 2.4 billion lb or 366 million gal in 1979, possibly 2.3 billion lb. This volume would mean that nameplate capacity of about 3.4 billion lb this year would be used at an average rate of just 68%. This is poor compared to rates for other major organic chemicals, although off only moderately from recent rates for cyclohexane.

Actually, cyclohexane will do well to come in even this close to 1979 production in 1980. The reason is a sizable market drop in progress in its major end use, nylon. For the first four months of 1980, nylon shipments were down 9% from the same period in 1979, according to the Textile Economics Bureau. And for fibers the worst may not be over.

Cyclohexane sources say that inventories may hold the key for cyclohexane stability this year. As 1980 began, inventories were low after a strong year in 1979. Factors were a good export business in 1979, considerable tightness in raw material benzene supply at times, and stout demand for nylon in carpets.

Hence, given low starting inventories, 1980 production of cyclohexane may hold up better than the general economic outlook suggests. Inventory building also may be helped by the value-added advantage of converting benzene to cyclohexane and by anticipation of an early bounce at the bottom of the recession. Even so, producers remember that nylon took two years to recover to its previous peak after the recession of 1974–75.

Amounts of cyclohexane going to major outlets are expected to fall off moderately for the full year in 1980. Exports, which account for about one sixth of production, will decline about 10% in 1980 or about 50 million lb. Carpet use, which accounts for well over half of nylon consumption, may fall sharply for a while, but chemical producers hope that aggressive promotion by carpet retailers will boost up sales later in the year.

Various other uses of nylon such as tire cord, apparel, and hosiery all face small changes in demand this year, in chemical producers' view. Tire cord use remains fairly strong because of the nonauto nature of this market, concentrated in truck, bus, and off-the-road vehicles.

In apparel markets, nylon is a mature fiber. A few of the many kinds of fabrics made with nylon could show sudden growth due to whims in fashion, but most are expected to hold where they are. Hosiery as a separate class of apparel use of nylon may show small growth but less than population growth.

On balance then, nylon probably will show a 1980 decline in carpet use offset partially by apparel. Cyclohexane exports will decline. The resulting net volume drop will be offset somewhat by inventory building to leave cyclohexane production a little lower than in 1979.

With nylon's negative outlook this year, cyclohexane's recent pattern of trailing nylon growth rates and excess capacity, can cyclohexane producers expect much at all in 1980 even in terms of their return on investment? Producers believe that several process factors still give them a chance.

For one, benzene weighs about 7.4 lb per gal, whereas cyclohexane weighs about 6.5 lb per gal. In effect, the hydrogenation of benzene produces more gallons of product. The product, although lighter, sells for 7 cents more a gal, or $1.72, compared to benzene's $1.65 by current postings.

Well, how about cyclohexane production costs? Certainly, there are operating costs for the raw material hydrogen and processing charges. However, depending on how the accounting is done, profitability doesn't have to be all that poor even with relatively low plant use rates. The accounting opens up many subjective estimates of costs, especially since all cyclohexane producers are petroleum refiners that can make their own starting materials. For example, the benzene going to cyclohexane can be considered incremental production, and the hydrogen can be priced low at its fuel value in the refinery's fuel gas stream.

Hence, even with a difficult year in 1980, producers of cyclohexane may not have so poor a year financially as economic conditions stemming from nylon demand would suggest.

Industry leery of natural rubber agreement

International pact would set up natural rubber stockpile to buffer price fluctuations, but many experts say system is unrealistic and won't work

Congress has cleared the way for the U.S. to take part in the International Natural Rubber Agreement.

Last month, both the House and the Senate passed legislation authorizing the appropriation of $88 million that the Administration requested to participate in what it is calling a "model commodity agreement." And the Senate, by a 90 to 1 vote, ratified the agreement.

That makes the U.S. the first major natural rubber importing country to ratify the agreement, which is supposed to become operative this October. Malaysia, by far the largest natural rubber producer, was the first country to ratify the agreement when it took the step earlier this year.

When the House Foreign Affairs Committee approved the appropriation, Rep. Jonathan Bingham (D.-N.Y.), chairman of the Subcommittee on International Economic Policy & Trade, told the committee that U.S. participation in the effort to stabilize natural rubber prices would in no way harm the U.S. rubber industry.

Perhaps not. But with the exception of the Rubber Trade Association (RTA), the U.S. rubber industry isn't particularly ecstatic about the proposition.

RTA, which is based in New York City, handles about 65% of all natural rubber imports into the U.S. and distributes them to all segments of the U.S. rubber industry. According to RTA president A. F. Scheuer, U.S. participation in the rubber agreement is preferable to having the producer countries go it alone.

The Rubber Manufacturers Association (RMA), however, is dead set against the agreement. First, it opposes the agreement on principle. RMA president Malcolm R. Lovell Jr. says that the association has always opposed artificial regulation of natural rubber's price and availability.

But RMA, which represents more than 200 U.S. manufacturers of rubber products, has a more practical reason for its negative attitude toward the agreement.

Most of the $88 million being earmarked for U.S. participation in the agreement will be used to build up an international natural rubber stockpile or buffer stock. This buffer stock, targeted to accumulate 550,000 metric tons of natural rubber, is designed to act as a stabilizing influence on natural rubber's price, which has a history of wild fluctuations.

The agreement calls for an initial reference price of about 45.4 cents per lb with bands of ±15% and ±20%. Thus, if natural rubber's price falls between 15 and 20% below the reference price, the buffer stock manager has the option of buying or not buying rubber for the stockpile. If the price falls below 20%, he must buy.

Similarly, on the high side, if the market price jumps to between 15 and 20% of the reference price, the manager can choose to sell or not sell. But if it goes more than 20% higher, he must sell.

The problem is that this price arrangement bears no practical relationship to today's natural rubber prices. Recent prices for RSS-1 grade (a reference grade) rubber have been running about 67 cents per lb on the New York market. They had been even higher until U.S. auto makers ran into trouble and pulled the skids out from under the tire market.

Even at 67 cents, natural rubber's market price is 48.6% above the proposed initial reference price under the agreement. It also is 12.5 cents above the upper 20%-band price, which means that the buffer stock manager would have to sell, not buy rubber under current market conditions.

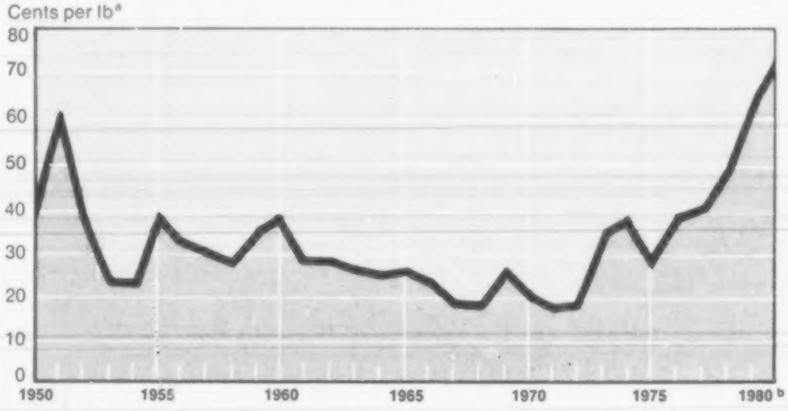
Given the budget constraints facing Congress, RMA's Lovell doesn't think that the $88 million should be appropriated when it is "abundantly clear that [it] cannot be used for the purpose proposed."

A. J. Ashe, senior vice president of B. F. Goodrich Co., is more explicit. "It's a waste of taxpayers' money," he says.

Personally, Ashe, with his background in economics, is opposed to anything that interferes with a free market. However, he considers himself a strong proponent of the agreement because it's "as good as we can get" and will have a minimum of interference in the market.

But Ashe, too, thinks that the timing is bad. Under today's market conditions, the buffer stock manager would have to sell natural rubber from the stockpile. But, Ashe says, he can't sell something he doesn't have. For the manager even to have the option of buying, the price of natural rubber would have to drop to about 38 cents per lb. And, with the price

Price instability behind natural rubber agreement



[a] Average price of RSS-1 reference grade on the New York market. [b] Through April 1980.
Source: World Bank data

Malaysia produces nearly half of world's natural rubber; U.S. consumes almost fourth of total

Output	% of total[a]
Malaysia	[illegible]
Indonesia	[illegible]
Thailand	12.0[illegible]
Singapore	4.41
Sri Lanka	4.37
Liberia	2.55
Nigeria	1.31
Zaire	0.79
Cameroon	0.51
India	0.20
Papua-New Guinea	0.15
Bolivia	0.08
Philippines	0.02

Consumption	% of total[b]
U.S.	24.76%
Japan	10.78
China	[illegible]
U.S.S.R.	7.15
West Germany	6.44
France	5.43
U.K.	[illegible]
Italy	4.16
South Korea	[illegible]
Spain	3.18
Canada	2.93
Poland	1.98
Brazil	[illegible]
Czechoslovakia	1.81
Romania	1.53
Other	11.80

a Percentage of net exports in the five-year period 1974 to 1978. b Percentage of net imports in the three-year period 1976 to 1978. **Source:** United Nations Conference on Natural Rubber

now running around 67 cents, Ashe doesn't see that happening soon. In fact, he doesn't think that the agreement will be able to operate as intended during its first five years.

So to Ashe, the proposed international rubber agreement is academic. And he thinks that the $88 million that the U.S. wants to spend on it will do little more than create an unnecessary bureaucracy and subsidize attendance at meetings around the world.

He even doubts that the agreement can do the job that it's designed to do. The proposed inner bands of ±15% amount to a 30% price spread, or a range of almost 14 cents. Although natural rubber prices have, indeed, fluctuated widely in the past, Ashe says that a 30% swing has happened only very few times in the past 20 years. So as a price stabilizer, he believes that the agreement is "nonsense."

One other thing that bothers some U.S. rubber companies is whether producing countries will take the steps necessary to guarantee increased natural rubber production. RMA's Lovell says the Senate shouldn't have ratified the agreement until it became apparent that producing countries, in fact, were attempting to increase output.

Such fears may be unfounded, however. Those familiar with the agreement say that it provides mechanisms for expanded production. And, unlike other commodity agreements, it virtually precludes use of export controls by producing countries.

Malaysia, which accounts for about half of all natural rubber exports, already has taken steps to encourage increased production. It has reduced export taxes on natural rubber about 20%. These taxes tended to encourage Malaysians to use their land for other crops, such as palm oil, instead of rubber. The country also has a billion-dollar development plan under way to boost rubber production.

However, these and other production incentives may not be enough. At a recent meeting of the International Institute of Synthetic Rubber Producers in Mexico, John J. Riedl, Goodyear's plantation manager, forecast tight natural rubber supplies in the 1980's. He estimates that natural rubber supply will increase an average 3.2% per year during the decade. But, he adds, demand probably will outdistance supply. Even pessimistic estimates peg 1990 worldwide natural rubber consumption at about 5.85 million metric tons. That's 52% higher than present rates. To reach that 1990 consumption figure, Riedl says, Malaysia and Indonesia, the two leading natural rubber producers, would have to increase their output 1.3 million tons, or about 300%. And they managed to raise production only less than 400,000 tons over the past 10 years.

Those are the economic realities facing the international rubber agreement when—and if—it becomes effective in October. To become effective, it must be ratified by governments accounting for at least 80% of net exports and governments accounting for at least 80% of net imports.

Earl Anderson, New York

Chemistry and the Food System

A Study Report by the ACS Committee on Chemistry and Public Affairs

Vital reading for everyone concerned with this important public policy issue.

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Attendant benefits, disadvantages, problems, and risks are all fully discussed with the aim of providing public policy makers with the necessary information and recommendations needed in their formulation of public policy.

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June 30, 1980

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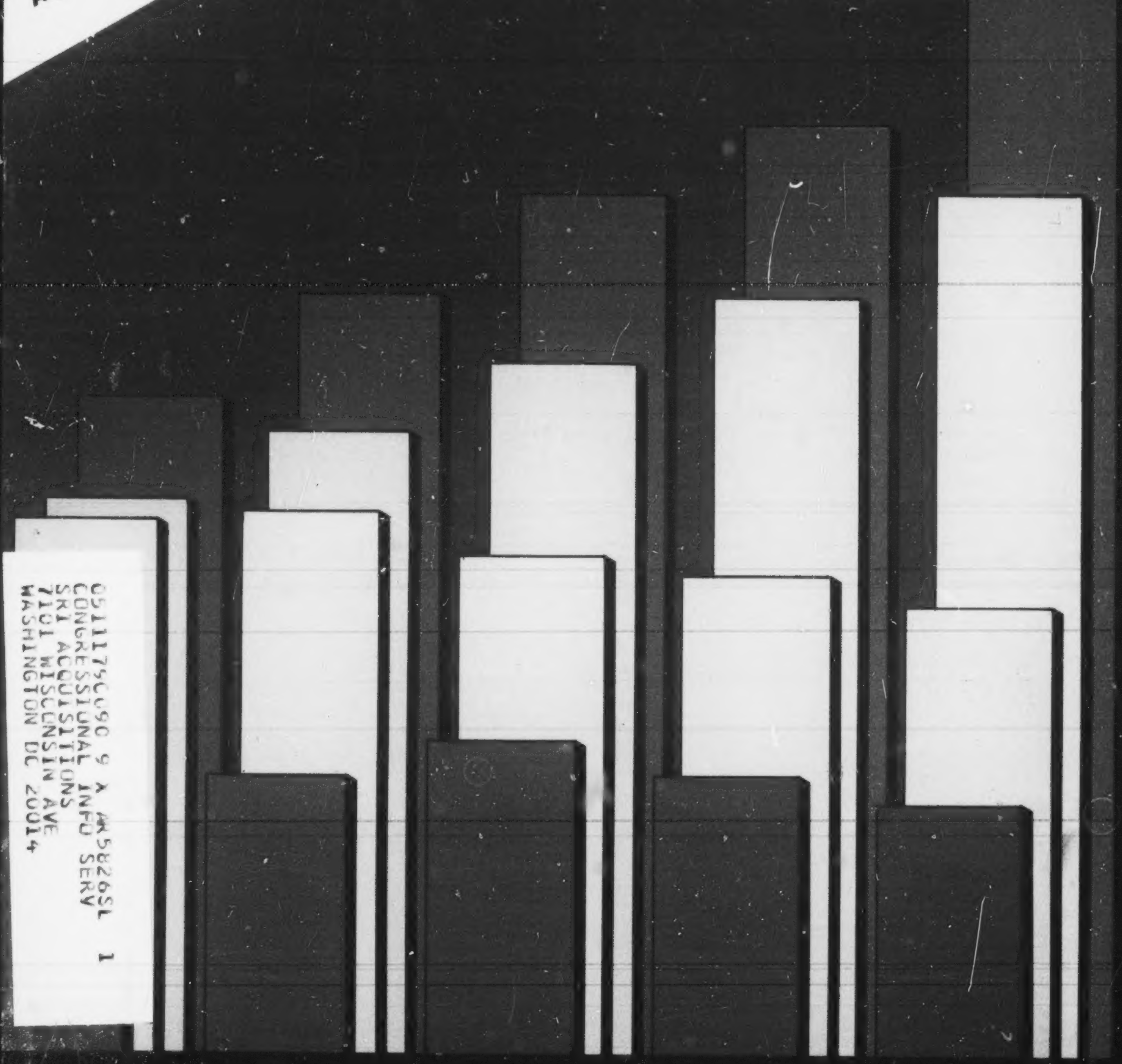

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Second Top 50 chemical firms a diverse group

Second 50 are more widely spread through U.S. industry than Top 50, have chemical sales ranging from about $150 million to nearly $1 billion

William F. Fallwell
C&EN, New York

Although not the place for a company without a lot of investment money and technology, commercial chemicals are far from being another auto or steel industry with only a few important producers. In fact, the spread of chemical operations through companies nominally making something completely different makes the very definition of the chemical industry a problem.

This diversity also gives rise to conflicting notions on the relative success of various chemicals under various parentage. Is it better to be big or small, commodity-oriented or specialized, organic or inorganic, oil- or natural gas-based, free-standing or buried in a conglomerate?

Some answers to these questions have emerged with C&EN's addition of a second Top 50 survey to its annual Top 50 listing (C&EN, May 5, page 40). These companies are ranked by worldwide basic chemical sales, not total sales. Since chemical sales for the 100th largest company are about a fairly low $150 million, the two surveys combined probably cover about 95% of all sales by U.S. basic chemical producers.

That 95% comes to about $110 billion for 1979. Within this total, there is a big difference between the smaller 50 and the larger 50. The first 50 account for about $90 billion of the total, and the second 50 for about $18 billion. Thus, the average chemical sales of the largest group are $1.8 billion, and for the smaller group $360 million.

The range in sales is also much smaller for the second 50 group. Whereas the Top 50 starts with Du Pont's $9.7 billion and ranges downward to less than $600 million, the second 50 covers a range of only a few hundred million dollars.

There is officially some overlap between the sales ranges of the two surveys because of the varying purity of company figures on their chemical sales. The first six companies in the second 50 list, starting with Goodyear, are all larger than the 50th company, NL Industries, on the first list. All six, however, mix in a variety of nonbasic chemical sales in their chemical sales figures and possibly wouldn't make the first 50 on basic chemical sales alone.

The seventh company in the second 50, Georgia-Pacific, is slightly ahead of NL Industries and probably should have been on the first 50 list. Otherwise, all companies in the second 50 are below the cutoff for the first 50.

The second 50 group is still not complete, reflecting the state of industry disclosure. Although companies have opened up considerably in the past few years in product line data, in part from nudging by the Securities & Exchange Commission, figures still leave some gap for chemical operations.

There are at least 12 companies whose chemical sales cannot be estimated properly but which should be on the second 50 list. Six of these are foreign-owned, four are highly diversified nonchemical companies, one is a cooperative, and one is private. Together, they have chemical sales of about $4.5 billion for 1979.

The foreign-controlled six are Henkel, Hoffmann-La Roche, ICI U.S., Sandoz, Soltex, and U.S. Borax. Henkel has reported its U.S. chemical sales in the past but later in the year.

The U.S. companies with unknown chemical sales are Avtex (private), CF Industries (cooperative), General Electric, Procter & Gamble, Sun, and Signal Cos. General Electric and P&G still issue annual reports reminiscent of 20 years ago in their lack of detail.

The variety in corporate type for this dozen is even more true for the companies on the second 50 list. They are much more widely spread through U.S. industry than are companies in the Top 50 group, which is dominated by chemical and oil companies. Al-

Second 50 chemical producers differ strikingly from Top 50

The U.S. chemical producers that rank 51st to 100th in terms of chemical sales are quite a different group from the Top 50 (C&EN, May 5, page 40). On average, the group of smaller firms doesn't have relatively so great a stake in chemicals as do the larger producers, and their chemical operations aren't growing so fast percentagewise. In absolute size, the second 50 pale beside the first. However, the second 50 are not dominated by chemical and oil companies. And the parent firms of the second 50 chemical operations generally are more profitable than are the Top 50 parents.

	Second Top 50	Top 50
CHEMICAL SALES		
Total	$18.2 billion	$90.2 billion
Average size	$360 million	$1.8 billion
Average 1979 growth	22%	26%
Average % of total company sales	37%	49%
PARENT COMPANY TYPE		
Chemical	19	29
Petroleum, including natural gas	8	14
Drug	4	0
Tire	4	1
PARENT COMPANY PROFITABILITY		
Average profit margin	7.5%	6.1%
Median profit margin	6.7%	5.9%
Average return on stockholders' equity	17.1%	16.5%
Median ROE	16.9%	15.7%

Most chemical producers in second Top 50 have chemical sales less than $500 million

							TOTAL COMPANY				
								Profit margin[a]		Return on stockholders' equity[b]	
Rank 1979	Company	Chemical sales 1979 ($ million)	Change from 1978	Total sales 1979 ($ million)	Chemical sales as % of total sales	Industry classification	Net income ($ millions)	Per cent 1979	Rank 1979	Per cent 1979	Rank 1979
51	**Goodyear**	$985[c]	17%	$8,239	12%	Tires	$146.2	1.8%	46	6.8%	45
52	**3M**	821[c]	18	5,440	15	Photographic equipment	655.2	12.0	11	22.2	7
53	**Firestone**	687[c]	21	5,284	13	Tires	112.9[d]	2.1	44	7.7	43
54	**Dart Industries**	627[c]	5	2,403	26	Basic chemicals	171.7[d]	7.2	24	16.2	30
55	**Farmland Industries**[e]	609[c]	10	3,860	16	Farm cooperative	93.4	2.4	42	20.2	11
56	**Koppers**	557[c]	15	1,828	30	Diversified chemical	86.5	4.7	33	14.7	34
57	**Georgia-Pacific**	542	58	5,207	10	Wood products	327	6.3	27	16.7	29
58	**Cities Service**	528	30	6,277	8	Petroleum	347.5	5.5	30	15.6	32
59	**Esmark**	516[c]	9	6,772	8	Meat products	92.4	1.4	47	11.1	40
60	**General Tire**	482[c]	7	2,295	21	Tires	81.7	3.6	38	8.2	42
61	**Eli Lilly**	471	40	2,206	21	Drugs	329.5	14.9	7	21.0	9
62	**Texasgulf**	464	36	789	59	Metal mining	136.9	17.4	2	15.7	31
63	**Uniroyal**	449	1	2,575	17	Tires	−120.5[d]	f	50	f	49
64	**Alcoa**	433[c]	17	4,847	9	Nonferrous metals	504.6	10.4	12	20.0	13
65	**Kerr-McGee**	420	12	2,683	16	Petroleum	160.0	6.0	29	13.2	36
66	**Kaiser Aluminum**	419	24	2,927	14	Nonferrous metals	232.2	7.9	19	19.0	16
67	**International Flavors**	409	12	409	100	Basic chemicals	61.5	15.0	5	21.5	8
68	**Freeport Minerals**	402	58	488	82	Nonmetallic minerals	101.4	20.8	1	26.7	4
69	**Badische**	398	25	398	100	Basic chemicals	15.5	3.9	36	11.0	41
70	**Standard Oil (Ohio)**	398	22	7,916	5	Petroleum	1186.1	15.0	6	38.4	2
71	**Cabot**	387	20	1,122	34	Specialty chemicals	70.4	6.3	28	18.4	18
72	**Pfizer**	384	11	2,746	14	Drugs	237.9	8.7	15	16.8	27
73	**Merck**	381[c]	20	2,385	16	Drugs	381.8	16.0	3	22.9	6
74	**El Paso**	334	62	3,089	11	Natural gas	138.1	4.5	34	17.4	22
75	**North American Philips**	329[c]	4	2,409	14	Electrical products	81.7	3.4	39	14.3	35
76	**Internorth**	327	39	2,499	13	Natural gas	185.5	7.4	21	17.2	25
77	**Airco**	325	18	911	36	Basic chemicals	67.6	7.4	22	na	na
78	**GAF**	301	21	1,213	25	Photographic equipment	28.2	2.3	43	7.6	44
79	**Upjohn**	301	16	1,508	20	Drugs	149.5	9.9	13	20.1	12
80	**American Petrofina**	297	77	1,587	19	Petroleum	83.2	5.2	31	19.3	15
81	**Liquid Air**	272	47	369	74	Basic chemicals	24.7	6.7	25	11.8	37
82	**Mississippi Chemical**	265	7	265	100	Farm cooperative	23.8	9.0	14	17.2	24
83	**Witco Chemical**	264	14	967	27	Basic chemicals	42.8	4.4	35	18.1	20
84	**Emhart**	258	19	1,346	19	Machinery	70.2	5.2	32	16.9	26
85	**Thiokol**	257[c]	38	557	46	Aerospace	40.1	7.2	23	19.6	14
86	**Martin Marietta**	243	19	2,061	12	Aerospace	178.0	8.6	16	18.4	19
87	**Vulcan Materials**	242	7	748	32	Nonmetallic minerals	63.8	8.5	17	20.9	10
88	**Terra Chemicals**	241[c]	29	254	95	Agricultural chemicals	2.7	1.1	49	5.9	46
89	**Beker Industries**	228	13	228	100	Agricultural chemicals	36.4	16.0	4	39.7	1
90	**SCM**	221[c]	16	1,754	13	Paint	47.4	2.7	40	11.4	38
91	**Royster**	197	41	228	87	Agricultural chemicals	3.0	1.3	48	4.4	48
92	**Houston Natural Gas**	195	11	1,798	11	Natural gas	138.6	7.7	20	19.0	17
93	**Northwest Industries**	192	2	2,580	7	Conglomerate	172.2	6.7	26	17.3	23
94	**Engelhard Industries**	177[c]	14	18,080	1	Commodity trading	349.7	1.9	45	31.0	3
95	**Big Three Industries**	173	21	509	34	Basic chemicals	62.9	12.4	9	15.6	33
96	**Petrolite**	172	15	187	92	Specialty chemicals	15.6	8.3	18	16.7	28
97	**Loctite**	161	26	161	100	Specialty chemicals	23.3	14.4	8	25.2	5
98	**First Mississippi**	157	9	178	88	Agricultural chemicals	4.7	2.6	41	4.9	47
99	**Getty Oil**	147	17	4,986	3	Petroleum	604.4	12.1	10	17.7	21
100	**Stepan Chemical**	145	18	145	100	Detergent chemicals	5.3	3.7	37	11.4	39

a Net income as percentage of net sales. **b** Net income as percentage of year-end stockholders' equity. **c** Chemical sales include significant amounts of nonchemical products such as fabricated plastics, coatings, metals, drugs, and the like. **d** Net income includes major nonrecurring items — Firestone $35.2 million credit, Dart Industries $48.4 million (pretax) credit, Uniroyal $87.9 million (pretax) charges. **e** Net income given as "savings," stockholders' equity as "capital shares and equities." **f** deficit. **na** = not available. **Note:** Data are for calendar year or for company fiscal year ending in 1979.

though there are 29 chemical companies of one kind or another among the Top 50, there are only 19 in the second 50.

Equally notable is the diminished role of oil and gas companies in the smaller company group. Petroleum companies have moved up steadily on the senior list, to the point that six of them are in the first 15 positions, with Exxon number three behind only Du Pont and Dow Chemical.

However, in the second 50, there are only eight petroleum companies, led by Cities Service. Three of these are heavily centered in natural gas—El Paso, Internorth, and Houston Natural Gas.

From these two clusters in chemical and oil companies, the second 50 list scatters through 13 other industry categories, running from heavy machinery and aerospace to conglomerates and commodity trading. Two of these with a notable presence are tires and drugs.

Since the second 50 list is so dispersed throughout U.S. industry, it would be expected that the chemical influence in these firms would be less than in the Top 50 companies. The average unweighted chemical part of total sales in the second 50 is 37%, below the 49% average for the Top 50.

Though operating from a smaller sales base, the second 50 chemical operations grew relatively less in 1979 than did the Top 50, largely because of the weight of booming petrochemicals in the larger companies. Average unweighted growth among the second 50 chemical operations was 22% in 1979 compared to 26% for the Top 50.

However, the smaller 50 companies show their strength on the bottom line as do smaller companies in numerous other financial comparisons with larger chemical producers (see C&EN's scan of comparative financial ratios of 40 major chemical companies, June 9, page 47). For total company results, profit margin on sales for the second 50 averaging 7.5% in 1979 (median 6.7%) is a cut above the average 6.1% (median 5.9%) for the Top 50 companies.

The difference narrows in average return on stockholders' equity. For the second 50, average ROE at 17.1% is still above the average 16.5% for the Top 50. Respective medians are 16.9% and 15.7%.

This recession year won't offer many of these companies a chance to repeat 1979 performance. However, growth like this in the business expansion just ended shows plenty of investment and profitability in smaller chemical company operations. ☐

CHECKOFF

MERGERS

■ **Allied Chemical**—Sells its Minerva fluorspar mining complex, Cave-In-Rock, Ill., to Inverness Mining Co. for cash and notes; terms not disclosed. Allied had closed two mines and processing plants last year. Inverness, subsidiary of Seaforth Oil & Mineral, says it will reopen mines and bring them to full production within three months.

■ **Cabot Corp.**—Agrees in principle to sell its machinery division to Ingersoll-Rand for $130 million and assumption of certain liabilities. Division manufactures mobile equipment for drilling, service, and workover of oil and gas wells and manufactures high-grade steel products. Cabot will use proceeds to fund capital expenditures to fund oil and gas exploration and development and expansion of its specialty metals businesses.

■ **Dow Chemical**—Completes sale of Tennessee operations of its Hydroscience subsidiary, based in Knoxville, to IT Corp., hazardous waste management firm. Hydroscience, involved in development, design, and engineering of solids, thermal, and air pollution control systems, will be known as IT Enviroscience Inc. Terms not disclosed.

■ **Du Pont**—Cancels merger discussions with Shipley Co. of Newton, Mass.

■ **W. R. Grace**—Purchases National Kaolin Products Co. of Aiken, S.C., for $5.5 million in Grace common stock. National Kaolin, supplier of air-floated clay to rubber industry where it is used as filler in batching of synthetic and natural rubbers, had 1979 sales of about $1.8 million.

Grace also acquires McDonald Rental Tools of Lafayette, La., and DCI Inc. of Tulsa, Okla., both oil field service companies. McDonald was acquired for $16.5 million in cash; DCI for $4.1 million in Grace common stock.

■ **Guardsman Chemicals**—Agrees in principle to acquire all outstanding stock of Technical Research for cash, notes, and stock. Technical Research, with annual sales of about $4 million, manufactures industrial finishes and operates manufacturing facility in Seattle area, with markets in Northwest.

■ **Hercules**—Signs letter of intent providing for purchase of its St. Paul Equipment division by Allpak Ltd. of London, Ont. St. Paul Equipment makes filling equipment for dairy, juice, food, cosmetic, and household chemical products. Purchase, subject to approval by both managements, will become effective July 28.

Hercules subsidiary Haveg Industries sells its manufacturing facility at Santa Fe Springs, Calif., to group of investors including many plant employees. Plant makes custom-molded reinforced plastic structures for industries such as aerospace and electronics. New company to be called Haveg-Reinhold Inc.

■ **International Minerals & Chemical**—Sells certain assets that had comprised its 40,000 ton-per-year sodium chlorate plant at Orrington, Me., to Stamchem division of PPG Industries Canada. Sale includes process machinery and ancillary equipment which Stamchem will move to its Beauharnois, Que., site; terms of sale not disclosed.

■ **Interox America**—Acquires all of Shell Chemical's hydrogen peroxide rolling stock and services of Shell's major terminal storage facilities.

■ **PQ Corp.**—Sells its QURAM quaternary ammonium product to Emery Industries, subsidiary of National Distillers. Agreement covers PQ's entire QURAM business including patented technology, production equipment, and trademark; terms not disclosed.

■ **Thiokol**—Completes purchase of Cincinnati Milacron's wholly owned subsidiary Cincinnati Milacron Chemicals, and related distribution assets outside U.S.; purchase price of $52 million in cash.

■ **Union Carbide**—Agrees to sell its Gamma Camera product line to Trans Union Leasing Corp.; terms not disclosed.

Polyurethane use may grow 9% annually

U.S. will account for almost 80% of 1980's expected use of some 2.8 billion lb in western hemisphere; fastest growth will be in elastomers

Overall polyurethane demand throughout the western hemisphere is expected to exceed 4.3 billion lb in 1985. If that prediction is realized, it means that use of the polymer will grow at an average rate of more than 9% annually.

The countries in this hemisphere all are subject to challenges that will impinge on their polyurethane markets, according to Peter J. Manno, manager of commercial development and market research at Upjohn's polymer chemicals division in La Porte, Tex. He cites inflation, dollar devaluation, and rising oil prices. Many of them have high unemployment and low living standards.

Manno presented this market analysis at an International Conference on Cellular and Noncellular Polyurethanes that drew 1300 delegates to Strasbourg, France. The meeting was cosponsored by the (U.S.) Society of the Plastics Industry and by West Germany's Fachverband Schaumkunststoffe (Union of Foamed Plastics).

Demand for polyurethanes may grow fastest in Venezuela

Millions of lb	1980	1983	1985	Average annual growth, 1980–85
U.S.	2191.2	2877.6	3429.8	9.4%
Canada	160.6	198.0	233.2	7.7
Brazil	158.4	180.4	209.0	5.7
Mexico	105.6	136.4	180.4	11.3
Argentina	52.8	61.6	70.4	5.9
Venezuela	50.6	72.6	92.4	12.8
Others[a]	61.6	79.2	96.8	9.5
TOTAL	**2780.8**	**3605.8**	**4312.0**	**9.2%**

[a] Other Caribbean, Central and South American countries. **Source:** Upjohn Co.

Indeed, since preparing his paper last fall, Manno has scaled down his estimates of 1980 polyurethane consumption, because of the effects of the deepening recession, particularly in the U.S. But he is optimistic that recovery will be evident by 1983, and that his 1985 forecasts will hold.

The U.S., where polyurethane consumption is by far the highest, will account for nearly 80% of this year's expected use of more than 2.8 billion lb in the western hemisphere. Then follow Canada, with 6% of total consumption, Brazil 6%, Mexico 4%, Argentina 2%, and Venezuela 2%. The other countries collectively account for the balance. The pattern should be much the same in 1985, except that Venezuela probably will have moved ahead of Argentina.

Venezuela, in fact, will experience the fastest rate of annual polyurethane growth in the coming five years, at nearly 13%. Mexico will come a close second, averaging more than 11% per year. "Venezuela," Manno notes, "is beginning to export polyurethane products to neighboring South American countries. And Mexican demand for consumer products is growing sharply."

Foams, both flexible and rigid, comprise the bulk of polyurethane sales. Demand throughout the Americas this year, according to Manno, likely will exceed 1.8 billion lb, almost 66% of total polyurethane use in these countries. Sales of elastomers, the next most important single class of polyurethanes, likely will be about 257 million lb this year, slightly more than 9% of the total. The 693 million lb balance, almost 25% of the total, consists of a variety of polyurethane-based formulations used in adhesives, coatings, sealants, and other applications.

Looking ahead, Manno predicts that foams will undergo an annual growth of more than 8% per year to some 2.7 billion lb in 1985, 63% of the total polyurethanes used that year throughout the hemisphere. Elastomers will grow faster, approaching 12% per year to about 449 million lb, or 10% of the total. Demand for other products will expand about 10% per year to more than 1.1 billion lb in 1985.

The bulk of the flexible foams go to make cushion fillings and mattresses. This market has been hard hit by the slowdown in construction and home sales, which has caused a drop in demand for furnishings and bedding, Manno says. Flexible foams, together with rigid foams, also are used in auto interiors for seats and protective padding.

C&EN staff photos

Manno: 1985 forecasts will hold

Rigid polyurethane foams are employed in buildings because of their desirable thermal insulation properties. "A recent outlet in the U.S. that has proven to be quite excellent is use of rigid foam sheets in residential homes," Manno says. These sheets are less than an inch thick with an

Leis: big growth in autos

Construction will pace polyurethane use in Americas

Millions of lb	1980	1983	1985	Average annual growth, 1980–85
Foams				
Furniture & bedding (flexible)	899.8	1053.8	1234.2	6.5%
Transportation (flexible & rigid)	464.2	574.2	635.8	6.5
Construction (rigid)	314.6	490.6	633.6	15.0
Refrigeration (rigid)	151.8	198.0	231.0	8.8
Elastomers[a]	257.4	363.0	448.8	11.8
Others[b]	693.0	926.2	1128.6	10.3
TOTAL	**2780.8**	**3605.8**	**4312.0**	**9.2%**

a Includes footwear. b Includes appliances, foundry core binders, carpet underlay, fibers, textile laminates, and packaging. **Source:** Upjohn Co.

outer skin of aluminum foil. They provide a high level of insulation, increasingly important in light of the rising costs of heating and air conditioning.

Although sales of rigid polyurethane foam for building and construction likely will increase 15% per year through 1985 in the U.S. from the present 271 million lb, growth rates in Venezuela and Mexico will be even faster. Admittedly starting from lower bases, in Venezuela the growth rate is expected to be 20% per year (from 4 million lb now), and nearly 19% in Mexico (from close to 7 million lb).

The thermal barrier characteristics of polyurethane foams is the reason, too, for their increasing use both in home refrigerators and freezers, and in commercial refrigeration units. By Manno's estimates, 80 to 85% of U.S.-made refrigerators and about 90% of freezers use them. This outlet will amount to 110 million lb in 1980 in the U.S. alone—73% of consumption in the Americas—and could grow almost 8% annually in the next five years. The fastest yearly growth rate will be in Mexico (19% from the present consumption level of 7 million lb) and Argentina (15% from 2 million lb).

Autos will provide an increasingly important outlet for polyurethane elastomers, Manno says. He cites the weight savings, which will result in economies in gasoline consumption, and the styling flexibility.

Donald G. Leis, senior marketing consultant for Union Carbide's silicones and urethane intermediates division in New York City, shares this opinion. By 1990, he predicts, the amount could grow more than fourfold to nearly 331 million lb from the 68 million lb of polyurethane elastomer used in 1979 U.S. models.

"As the weight of the [U.S.-made] car is reduced [from an average of 4200 lb to 2600 lb in 1990], total use of plastics will increase 137% per car, and total use of urethane materials will increase 147% per car," he told the Strasbourg meeting. "This growth of urethane materials can be achieved only by continued development of the reaction injection-molding (RIM) process, and the successful commercial production of RRIM (reinforced rim) materials."

RIM is a recently developed technique involving injection of automatically metered urethane components into a mold. In RRIM a filler, such as glass fiber, is employed. "Currently, the material of choice for potential external automotive body parts is made from high-modulus urethane elastomer with between 15 and 25% milled glass fiber to give product with a flexural modulus of 1.7 to 2.1 MegaPascals," Leis notes.

"RRIM urethane elastomer should become a future major use for urethanes," he says. External body parts are 50% lighter than corresponding metal ones, have better corrosion resistance, and can withstand damage. "We project use of 4 lb per car in 1985, and 8 lb per car by 1990 if successful production can be achieved."

Automotive applications currently being considered for RRIM urethanes are fenders and door panels, according to Leis. "By 1981, there will be at least eight RRIM machines in the [U.S.] automobile industry," he says. "These will be captive machines, all dedicated to development of production of prototype parts. Something has to happen from that."

In one of the keynote addresses, Günther Oertel, head of Bayer's polyurethane applications department in Leverkusen, West Germany, provided some pointers on how he sees outlets for polyurethanes. One, for instance, is the possibility of molding shoe soles, or, indeed, complete shoes, by RIM technology.

Industrialized countries are finding it increasingly difficult to compete in price with shoes coming from countries where labor costs are very much lower, he notes. He sees a switch to RIM technology, with its fast cycle times and reduced labor requirements, as a possible answer.

Oertel: significant new uses

Replacement of conventional auto paints with ones based on polyurethane formulations is another area that could open up significant markets. Polyurethane paints, Oertel points out, cure rapidly at about 80° C in contrast to the 120° to 160° C needed for existing paints. "Right now, it's an untouched market," he says. In fact, he says, one auto company, which he won't name, plans to use polyurethane paint on its autos next year. "This should provide a strong push to the market."

Oertel touched on a sensitive issue for polyurethanes—their flammability. He urges wider study of the use of such inorganic fillers as mica or aluminum hydroxide. "These improve fire resistance to a significant extent," he notes. Besides, he adds, such materials add physical strength to polyurethane parts.

Another potentially fruitful area of research involves the polymerization reaction itself. Polyurethanes are made by interacting a diisocyanate with a polyether derived from propylene glycol. The blending of such a polyether with a second one, based, for example, on ethylene glycol, results in an emulsion. "The effect of a two-phase polyether system isn't fully realized," he says. "It should lead to a network of two elastomers, a two-phase system with completely different properties."

Neither has the blending of polyurethanes with other polymers been investigated in any detail, he adds. "Nobody knows what advantages or disadvantages might arise from blending 60% high-quality polyurethane elastomer with, say, 30% high-density polyethylene and 10% acrylonitrile-butadiene-styrene." These are some avenues his company is exploring, he hints. □

Inflation undercuts chemists' salaries

Very few chemists are without jobs this year and salaries are about 7% higher than they were a year ago, but surging living costs have more than wiped out the gain

For U.S. chemists, the employment situation continued to look very favorable during the early part of 1980. Very few chemists were unemployed and looking for work last March. And those with jobs were earning higher salaries than ever before. Nevertheless, the most recent ACS survey of the economic status of its members indicates that their salaries continue to be eroded by soaring living costs, as has been true generally for the past seven years.

Overall, in March, the median salary for chemists (that which is exceeded by 50% of those surveyed) was 7% higher than it had been 12 months earlier. Ph.D.'s salaries made a slightly better advance; chemists whose highest degree is either a B.S. or an M.S. did not do quite so well.

But living costs, as measured by the Department of Labor's consumer price index, were up a whopping 15% over the same 12-month period. Hence, on a constant-dollar basis, salaries have actually fallen about 7% during the year. That's the biggest bite inflation has taken out of chemists' salaries in at least the past quarter of a century. After adjustment for price increases in recent years, chemists' median salaries this year are nearly 20% lower than they were in 1973. They are, in fact, at about the same level as they were in the early 1960's.

No single chemist, of course, remains at the overall median throughout his or her career. Individual salaries, for one thing, depend on experience, with younger chemists typically earning less than the median while older chemists earn more.

Thus, in 1975 the median salary for a chemist who had gone to work after graduating with a B.S. degree in 1967 was $15,100 a year. In 1980, now 13 years after graduation, his salary, if he earns the median, is $23,450, 55% more. His salary has gone up about 9% a year. During the same period, meanwhile, consumer prices have increased about 52%. So his salary hasn't declined, in real dollars. But after five years of work, he essentially is earning just about the same as before. Ten years ago, this "median" chemist would have had a salary of $10,000 a year. Now, he is making about 135% more, for an average annual gain again of 9%. But with the cost of living nearly 110% higher, his current salary, in 1970 dollars, comes to merely $11,200, which works out to an increase of only about 1% a year.

If he were older, he likely would have fared even worse. The median salary this year for a B.S. chemist who obtained his degree 33 years ago is $30,000. That's 36% more than he had been making five years earlier and

Nearly all ACS members were employed last March. . .

Employment status[a]	Chemists								Chemical engineers	All ACS members[c]
		By sex		By highest degree			By minority status			
	Total	Men	Women	B.S.	M.S.	Ph.D.	Minority[b]	Nonminority		
Employed full-time	94.9%	95.8%	88.6%	95.6%	95.9%	94.3%	92.9%	95.0%	96.9%	94.8%
Employed part-time	1.0	0.6	3.6	1.3	1.4	0.7	0.6	1.0	1.0	1.1
Postdoctoral or fellowship	2.2	2.0	3.3	0.1	0.2	3.8	4.6	2.0	0.2	1.9
Unemployed										
Seeking employment	0.9	0.7	1.8	1.4	1.0	0.6	1.4	0.8	0.5	1.0
Not seeking employment	1.1	0.9	2.7	1.7	1.6	0.6	0.5	1.1	1.4	1.1

a As of March 1, 1980 b Black, American Indian, Asian or Pacific, Hispanic. c Includes members whose highest degree and present work is in neither chemistry nor chemical engineering.
Source: ACS survey

. . .but their salaries were only moderately higher than previous year

$ Thousands	1980	1979	1978	1977	Change, 1979-80
CHEMISTS' MEDIAN SALARIES					
B.S	$25.0	$23.5	$22.0	$21.0	6%
M.S.	26.0	25.0	24.0	22.0	4
Ph.D.	31.2	29.0	27.4	26.0	8
Weighted average					7%

Source: ACS survey

$ Thousands	1980	1979	1978	1977	Change, 1979-80
CHEMICAL ENGINEERS' MEDIAN SALARIES					
B.S.	$35.0	$31.7	$30.0	$28.0	10%
M.S.	35.0	31.5	32.0	30.0	11
Ph.D.	38.0	35.0	32.0	30.0	9
Weighted average					10%

Joblessness among chemists remains at low level

Employment status, total U.S.[a]	1980	1979	1978	1977	1976
Employed full-time	95.9%	95.0%	95.7%	95.4%	94.7%
Employed part-time	1.0	2.0	1.0	1.1	1.3
Postdoctoral or fellowship	2.2	1.9	1.9	2.1	2.2
Unemployed	0.9	1.1	1.4	1.5	1.9

[a] Excludes unemployed chemists not seeking employment. **Source:** ACS survey

% Unemployed, by region[a]	1980	1979	1978	1977	1976
Pacific	1.5%	1.5%	2.6%	2.3%	3.0%
Mountain	0.9	0.3	1.7	2.7	2.2
West North Central	0.5	1.0	1.6	0.9	1.0
West South Central	1.0	0.9	0.8	1.0	0.7
East North Central	0.6	1.0	1.1	1.2	1.3
East South Central	0.2	0.3	0.8	0.7	1.5
Middle Atlantic	0.8	1.4	1.3	1.7	2.4
South Atlantic	1.0	1.3	1.5	1.2	1.5
New England	0.9	1.3	1.8	1.6	2.7

about 80% more than he would have been earning in 1970, assuming he had remained at the median during the decade. These increases are far below the concurrent rise in consumer prices during the same period. In fact, the $16,500 salary of this chemist in 1970, 23 years after he went to work with his new B.S. degree, has shrunk to just $14,300 this year when measured by the buying power of 1970 dollars.

If chemists' earning power has been eroded by inflation during the 1970's, their job security has improved a bit, at least compared to eight or nine years ago. This March, only 0.9% of the chemists responding to the 1980 ACS survey of the job situation for the chemical profession were unemployed and looking for work, down slightly from the 1.1% rate of a year earlier. This is the lowest unemployment rate since ACS began such surveys of its members in 1971. The unemployment rate for chemists has been falling each year since 1976, when 1.9% were out of work. The peak level of unemployment was 3.2% in 1972.

Joblessness among chemists has been consistently far below that for the total U.S. labor force. Last March, 6.2% of all civilian workers were unemployed. The national rate of unemployment had been hovering around 6% or slightly below for about two years. Since then, however, it has suddenly climbed as the U.S. economy sank deeper into recession. Last month, it reached 7.8%, the highest rate since late 1976.

Whether the current swift and sharp surge in joblessness nationwide will result in higher unemployment for chemists as well cannot yet be substantiated. But in the two most recent periods when unemployment rose rapidly in the U.S., during the recessions of 1970 and 1974–75, a smaller but still quite distinct increase in job losses struck chemists also.

Nevertheless, the job market has remained unusually strong for chemists throughout the first half of 1980, at least insofar as strength is reflected by the volume of advertising for job openings. C&EN is the major U.S. publication for classified ads listing positions available to chemists and chemical engineers. During the first five months of 1980, it carried 29% more such ads than in the like period of the previous year. Job ads in C&EN have not been so high any time since 1967. In May alone, ad volume was 43% higher than during the same month of 1979. However, preliminary figures for June hint, although still inconclusively, that a decline now may be beginning in ad volume.

Unemployment is generally at rock-bottom levels for chemists, no matter where or for whom they work or what they do. It appears to be a bit higher in the Far West than elsewhere, as has been the case during the three previous years. But the variation from one geographical area to another is not especially great. It is higher, too, although not markedly so, for younger chemists, as also was true during the three previous years.

Fewer women chemists, too, are unemployed but looking for employment this year than for any other year since the ACS survey began, although the rate for women, at 1.8%, continues

Salaries paid by industry tend to be above average at all levels of education and experience

	CHEMISTS' ANNUAL SALARIES ($ THOUSANDS)[a]															
Years since B.S. degree	0 to 1		2 to 4		5 to 9		10 to 14		15 to 19		20 to 24		25 to 29		30 to 34	
Percentile	All	Industrial	All	Industrial	All	Industrial	All	Industrial	All	Industrial	All	Industrial	All	Industrial	All	Industrial
25%																
B.S.	$13.2	$14.6	$14.5	$15.4	$17.0	$18.3	$20.0	$21.0	$23.0	$23.5	$25.0	$25.2	$26.5	$28.0	$25.0	$26.0
M.S.	—	—	14.5	17.1	17.0	19.2	20.0	22.1	22.1	25.5	23.0	27.0	26.0	28.8	26.2	29.0
Ph.D.	—	—	—	—	20.7	25.0	21.5	27.0	24.0	31.0	25.2	33.6	28.8	36.0	29.8	36.1
MEDIAN																
B.S.	16.2	17.4	17.0	17.2	20.0	21.0	23.4	24.0	28.0	28.1	30.0	30.0	31.2	32.9	30.0	31.2
M.S.	—	—	18.2	19.2	20.5	21.6	24.0	25.0	28.0	30.0	28.8	33.0	31.0	33.6	33.2	35.0
Ph.D.	—	—	—	—	25.5	26.8	27.0	30.0	30.5	36.0	32.4	39.0	36.0	42.0	38.0	41.9
75%																
B.S.	18.5	18.7	18.8	19.6	23.6	24.5	28.0	28.5	33.0	33.5	34.9	35.0	38.0	40.0	37.5	40.0
M.S.	—	—	20.0	21.7	24.0	24.5	27.9	29.5	33.2	36.0	35.8	40.0	39.3	41.0	39.0	40.0
Ph.D.	—	—	—	—	28.0	29.0	32.0	34.1	38.0	41.3	40.0	45.0	44.5	50.0	48.0	53.3

[a] As of March 1, 1980. **How to read this table:** Using as an example B.S. chemists two to four years after having received their B.S. degree, 25% of these chemists earn $14,500 a year or less, 50% earn $17,000 a year or less, and 75% earn $18,800 a year or less, as of March 1, 1980. **Source:** ACS survey

Unemployment slightly higher for chemists under 30

Age	% in category	% unemployed[a]
20-24	2.2%	1.9%
25-29	10.6	1.5
30-34	15.2	0.7
35-39	16.6	0.7
40-44	13.4	0.6
45-49	11.7	0.7
50-54	11.6	1.0
55-59	11.3	0.8
60-64	7.5	0.7

a As of March 1, 1980; excludes unemployed chemists not seeking employment. **Source:** ACS survey

to be double or more than for men. As in earlier surveys, too, a considerably larger percentage of women than men are working part-time, doing postdoctoral work, or are neither working nor looking for work.

Chemists account for 80% of the respondents to the ACS survey. Just over half of the remaining 20% are working as chemical engineers, with the balance being ACS members whose highest degree is in some field other than chemistry or chemical engineering (such as business) and who are working neither as chemists nor engineers. Chemical engineers' unemployment rate of 0.5% is below even that for chemists. However, for members whose career is in a nonchemical area, the rate is a considerably higher 2.3%.

These data on the job status of the chemical profession are obtained from about 16,000 responses to a survey conducted by the Office of Manpower Studies of the ACS Department of Professional Relations & Manpower Studies in March of a sample of 26,000 ACS members. The sample was limited to members who are under 65 years of age, live within the 50 states of the U.S. or the District of Columbia, and are not student or emeritus members. In a special effort to measure in detail the economic status of women chemists, this year's survey covered nearly all women who belong to ACS.

As in the past, chemists working for private industry or the federal government tend to earn more than those employed by academic institutions, nonprofit organizations, or elsewhere. There is little distinction, however, between industry and government. The median salary of Ph.D.'s in industry is $36,000, a $1900 advantage over Ph.D.'s in government. On the other hand, medians for chemists whose highest degrees are either a B.S. or an M.S. are higher if they are federal employees than if they are industrial chemists.

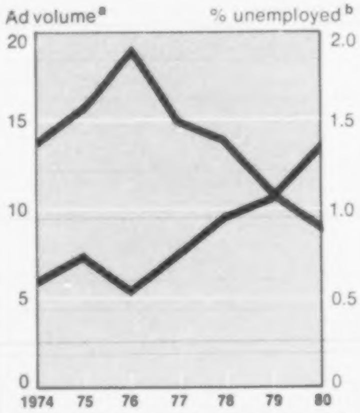
Approximately 60% of all chemists work in industry, and this year's survey provides information for the first time regarding differences in salaries among various industries. As would be expected, more industrial chemists (34% of the total) work for companies that manufacture chemicals than in any other industrial segment. Their salaries tend to be higher, also, than those of chemists working in other industries. The top dollar, however, is paid to chemists working for the petroleum industry, where 5% of industrial chemists are employed. Median salaries tend to be lowest for chemists with jobs with coatings producers, food companies, and nonmanufacturing firms.

Variations can be wide within a single industry, though. For example, salaries paid to Ph.D. chemists tend to be high—the median is second only to that in the petroleum industry—if they work for the pharmaceutical industry, which ranks second to the chemical industry in the number of chemists it employs. But the median salary for chemists whose highest degree is a B.S. or an M.S. is relatively low at pharmaceutical firms.

This year's ACS survey also pro-

35 to 39		40 or more		Overall	
All	Industrial	All	Industrial	All	Industrial
$27.0	$27.3	$25.4	$28.4	$18.7	$19.7
25.0	28.0	24.9	27.5	20.1	22.8
30.0	37.0	30.0	36.1	25.0	29.5
34.0	35.0	31.5	32.0	25.0	25.2
32.1	35.0	30.9	31.0	26.0	28.5
40.0	44.0	40.0	46.0	31.2	36.0
43.5	44.0	41.9	43.2	32.0	33.0
40.0	42.1	40.0	40.0	33.8	35.7
49.0	54.4	50.1	59 0	40.0	44.0

Strong job market reflected in ads and unemployment



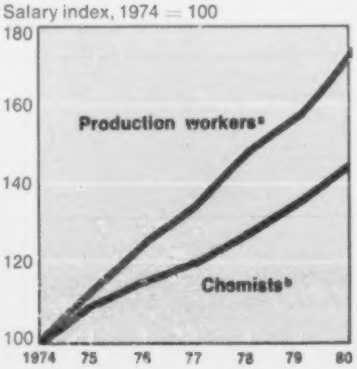
a Volume of help wanted advertising (in thousands of column inches) in C&EN for the 12 months ending with February of each year. b Per cent of chemists unemployed but seeking employment as of March 1 of each year.

Unemployment is low wherever chemists work

	% in category	% unemployed[a]
MOST RECENT EMPLOYER		
Industry	60.1%	0.9%
Chemical	20.7	0.9
Other	39.3	0.9
Education	24.9	0.5
Government	9.5	0.4
Nonprofit	4.6	1.8
Other	1.0	3.1
MOST RECENT WORK FUNCTION		
R&D	37.1%	0.6%
Teaching[b]	22.6	0.4
Management[c]	20.1	0.7
Marketing, production	11.8	1.7
Other	8.4	1.9
MOST RECENT WORK SPECIALTY		
Analytical	19.3%	1.1%
Organic	17.6	0.6
Polymer	11.2	0.5
Biochemistry	8.3	0.7
Pharmaceutical	8.0	1.0
Physical	6.9	0.6
General	6.9	0.9
Environmental	6.2	1.1
Inorganic	5.7	0.4
Other chemical	5.4	1.9
Agricultural, Food	4.6	1.3

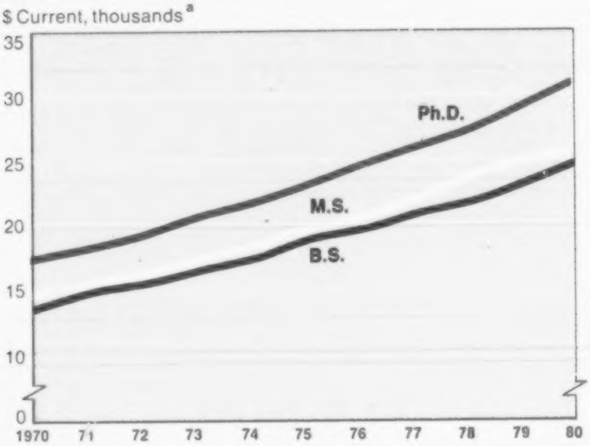
a Excludes unemployed chemists not seeking employment. **b** In universities and colleges only. **c** Includes R&D management. **Source:** ACS survey

Plant workers' wages outgain chemists' salaries

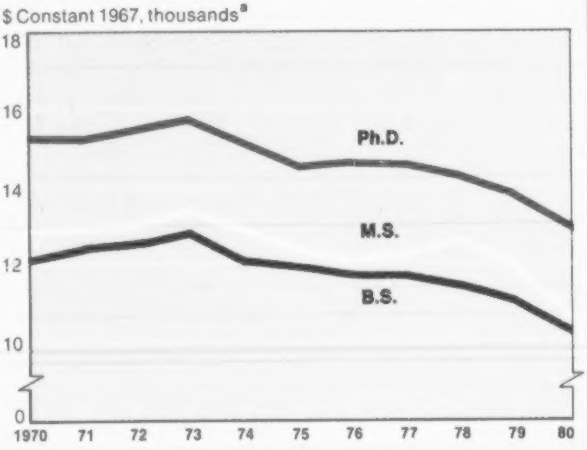


a In chemicals and allied products industry. b With B.S. degree. **Note:** Index based on data for March of each year. **Sources:** Department of Labor, ACS survey

Growth continues for chemists' salaries . . .



. . . but inflation obliterates the advance



a Median annual salary of chemists as of March of each year. **Source:** ACS survey

vides more insights regarding the range of salaries within the academic community than had been obtained previously. The results indicate that there is little difference between salaries paid by public or private universities that have graduate schools offering a Ph.D. in chemistry. About 60% of all academic chemists teach at such universities. For schools that do not confer the Ph.D., however, median salaries are higher at those that are public than at those that are private. The difference in salaries can be substantial between Ph.D.-granting universities and schools that do not offer such a degree. For example, the median salary for full professors at Ph.D.-granting schools, at $35,000, is 50% higher than that for professors of the same rank teaching at a private college where a B.S. is the highest degree in chemistry offered.

Salaries of women chemists continue to be well below those of their male colleagues, on the whole, whatever type of work they do or wherever they are employed. The median salary for women with a B.S. degree, for example, is $19,100 a year, compared to $26,000 for men. For women with an M.S., the median is $21,500; for men it is $27,300. At the Ph.D. level, the women's median is $24,700; the men's median is $32,000. On the face of it, women appear to earn only 75 to 80% as much as their male counterparts. The spread between women's and men's salaries has narrowed, but not much, in recent years.

The differences in the overall medians, to be sure, at least in part re-

Chemists earn more working in industry or government, especially if they are managers

	B.S.				M.S.				Ph.D.			
$ Thousands[a]	All chemists	Men	Women	Women as % of men	All chemists	Men	Women	Women as % of men	All chemists	Men	Women	Women as % of men
BY EMPLOYER												
Private industry	$25.2	$26.8	$19.8	74%	$28.5	$29.1	$23.1	79%	$36.0	$36.0	$28.8	80%
College/university	13.5	14.0	13.3	95	19.4	20.0	16.4	82	25.0	25.4	19.9	78
Federal government	28.4	30.0	21.3	71	29.8	30.5	24.7	81	34.1	34.6	30.3	88
Other	20.0	21.2	16.8	79	21.4	22.4	18.0	80	29.0	29.8	24.0	81
BY WORK FUNCTION												
General management	$33.0	$33.2	$24.8	75%	$36.0	$37.0	$28.8	78%	$40.0	$40.0	$30.3	76%
R&D management	34.8	35.0	26.2	75	37.0	37.5	27.8	74	43.0	43.0	34.8	81
Basic research	20.2	23.2	18.3	79	24.9	25.0	21.0	84	32.9	33.2	27.2	82
Applied R&D	24.0	25.1	19.5	78	27.0	27.6	22.5	82	31.7	32.0	27.9	87
Production and quality control	22.2	23.0	19.0	83	24.8	26.0	20.0	77	31.8	31.8	24.2	76
Marketing	29.8	30.0	19.9	66	30.0	32.0	23.7	74	38.0	38.0	27.0	71
Forensic	20.5	21.0	17.7	84	22.6	23.4	20.6	88	26.6	26.7	26.1	98
BY SPECIALTY												
Analytical	$23.0	$24.0	$19.2	80%	$26.0	$27.0	$22.0	81%	$29.6	$30.0	$25.3	84%
Organic	28.0	29.0	19.9	69	28.6	29.9	21.6	72	30.0	30.0	23.5	78
Polymer	28.0	28.9	20.0	69	29.4	30.0	22.4	75	37.0	37.2	27.2	73
Biochemistry	20.5	22.5	17.0	76	22.3	25.2	18.1	72	30.1	31.2	23.0	74
Pharmaceutical	22.0	24.0	18.9	79	26.5	27.0	24.0	89	36.0	36.8	28.8	78
Inorganic	27.0	28.0	19.7	71	28.1	28.2	20.0	71	28.3	28.6	23.0	80
Physical	24.0	25.4	18.6	73	30.0	30.0	25.0	83	30.0	30.3	25.0	83
Environmental	23.0	24.2	17.9	74	25.0	26.7	21.0	79	32.0	32.0	27.5	86
Agricultural, food	27.0	28.0	18.7	67	29.0	30.0	23.2	77	32.7	33.0	27.1	82

a Median salaries as of March 1, 1980. **Source:** ACS survey flect differences in length of experience and in the type of work with which women chemists are most frequently involved. Salaries tend to be higher for older chemists, for one thing, who are much more likely to be men than women. For instance, only about 20% of women chemists received their B.S. degree in 1955 or before; nearly 40% of the men did, however. Conversely, 37% of the women but only 15% of the men have earned their B.S. since 1970.

In addition, a larger proportion of men (62%) than women (53%) work in industry, where salaries are higher. Women also are less likely than men to have relatively high-paying management jobs. (Median salaries rise dramatically as the number of subordinates, either direct or indirect, expands.) Only 12% of women chemists hold positions involving either general or R&D management, whereas 28% of the men do—and median salaries for the relatively few women that hold such jobs is only 75% that of male managers. In academic institutions, too, women are more likely to rank below men. Only 25% of women are full professors, whereas a third are assistant professors; among men, 55% are full professors, just 16% are assistant professors.

For younger chemists, though, the spread between men's salaries and women's salaries is not nearly so great. The median for women who have worked for two to four years after graduating with a B.S., for example, is $17,000 a year, identical with that for men in the same category. And the median for women with a Ph.D. and up to five years' experience is $25,000, only 2% lower than that for men with similar credentials. The median for women with a Ph.D. and up to five years' experience in industry actually is 2% more than that for similar men.

For both men and women, salaries tend to level off as they become older, especially if they do not have a Ph.D. This occurs about 25 years following graduation for chemists with a B.S. or an M.S. After that median salaries fluctuate at levels between $30,00 and $35,000 a year.

This plateauing is particularly evident for women chemists, even for those who have a Ph.D. The median for a woman with a B.S. who graduated between 1951 and 1955 is $25,450; for women who graduated between 1941 and 1945, it is the same. Women who graduated between 1941 and 1945 and then went on to earn a Ph.D. before working have a median salary of $27,800. That is only 7% more than women with a Ph.D. who received their B.S. between 1951 and 1955.

Industrial chemists earn highest salaries from oil firms

Industry	% of industrial chemists: All chemists	B.S.	M.S.	Ph.D.	Median salary ($ thousands): All chemists	B.S.	M.S.	Ph.D.
Chemical	34%	29%	32%	39%	33.0	$27.5	$30.0	$36.1
Pharmaceutical	17	14	20	17	30.6	24.0	26.0	37.8
Coatings	6	8	5	4	26.0	24.0	25.3	32.5
Petroleum	5	5	4	6	34.1	28.6	32.0	39.0
Food	5	6	C	4	27.5	22.5	27.0	32.0
Metals	3	5	3	2	26.3	24.0	28.8	35.0
Rubber	3	4	3	2	32.5	28.4	31.4	36.0
Paper	2	2	1	2	32.0	25.0	29.9	35.0
Other manufacturing	19	21	19	18	30.2	25.0	28.4	36.0
Nonmanufacturing	6	6	7	6	28.5	21.0	27.8	34.0

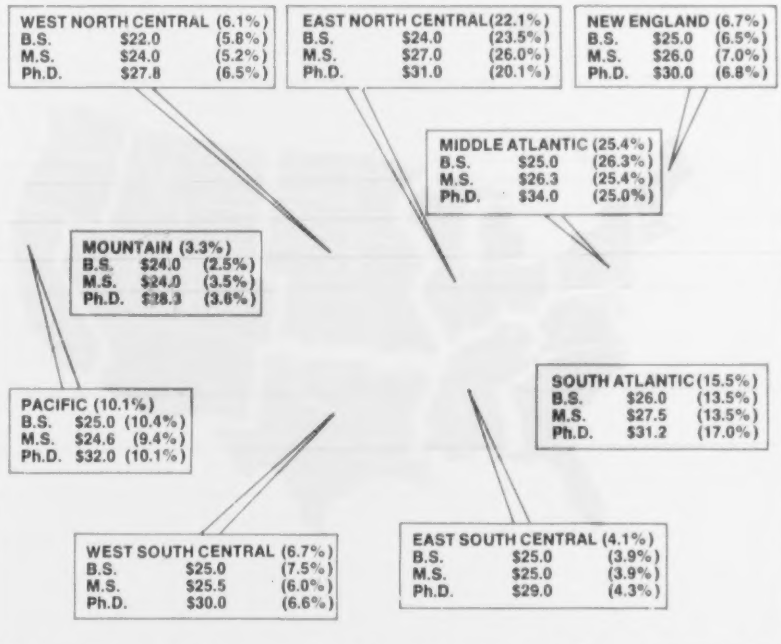
Source: ACS survey

Academic salaries are highest at Ph.D.-granting schools

Type of institution and highest degree awarded in chemistry	Median salary, Ph.D. chemists ($ thousands): Professor	Associate professor	Assistant professor	All Ph.D. chemists[a]
PRIVATE				
Ph.D.	$35.0	$25.0	$20.5	$28.0
M.S.	27.0	20.8	—	22.6
B.S.	23.0	18.0	15.2	19.5
PUBLIC				
Ph.D.	34.5	25.0	20.0	28.0
M.S.	27.5	21.0	17.5	24.5
B.S.	26.0	21.0	16.9	23.0
ALL UNIVERSITIES AND COLLEGES[b]	30.0	22.0	17.8	25.0

a Includes instructors, unranked teachers, and nonfaculty employees. b Includes schools where highest degree offered in chemistry is Associate. **Source:** ACS survey

Chemists' salaries tend to be a bit higher in the East


WEST NORTH CENTRAL (6.1%)
B.S. $22.0 (5.8%)
M.S. $24.0 (5.2%)
Ph.D. $27.8 (6.5%)
EAST NORTH CENTRAL (22.1%)
B.S. $24.0 (23.5%)
M.S. $27.0 (26.0%)
Ph.D. $31.0 (20.1%)
NEW ENGLAND (6.7%)
B.S. $25.0 (6.5%)
M.S. $26.0 (7.0%)
Ph.D. $30.0 (6.8%)
MIDDLE ATLANTIC (25.4%)
B.S. $25.0 (26.3%)
M.S. $26.3 (25.4%)
Ph.D. $34.0 (25.0%)
MOUNTAIN (3.3%)
B.S. $24.0 (2.5%)
M.S. $24.0 (3.5%)
Ph.D. $28.3 (3.6%)
SOUTH ATLANTIC (15.5%)
B.S. $26.0 (13.5%)
M.S. $27.5 (13.5%)
Ph.D. $31.2 (17.0%)
PACIFIC (10.1%)
B.S. $25.0 (10.4%)
M.S. $24.6 (9.4%)
Ph.D. $32.0 (10.1%)
WEST SOUTH CENTRAL (6.7%)
B.S. $25.0 (7.5%)
M.S. $25.5 (6.0%)
Ph.D. $30.0 (6.6%)
EAST SOUTH CENTRAL (4.1%)
B.S. $25.0 (3.9%)
M.S. $25.0 (3.9%)
Ph.D. $29.0 (4.3%)

Key to map: Using New England as an example, 6.7% of the responding chemists work in this geographical area; 6.5% of all whose highest degree is bachelor of science work there, and their median salary as of March 1, 1980, was $25,000 per year. **Note:** All salaries are in thousands of dollars. **Source:** ACS survey

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	B.S.	M.S.	Ph.D.
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0	$20.0	$23.0	$30.0
1–2	23.0	26.3	32.0
3–7	25.3	28.5	35.0
8–12	28.2	32.5	39.6
13–17	32.7	35.0	40.0
18–22	30.9	38.0	42.0
23–32	34.5	38.3	45.6
33–47	37.0	42.9	50.6
48–67	40.0	41.8	55.0
68–99	—	—	62.3
100 or more	52.0	55.0	73.0
PROFESSIONALS AND TECHNICIANS ONLY			
0	$20.2	$23.6	$30.2
1–2	23.0	26.2	32.0
3–7	26.0	29.0	35.1
8–12	30.0	32.7	39.7
13–17	32.7	36.0	41.2
18–22	35.0	40.0	44.2
23–32	40.2	41.4	46.0
33–47	43.0	42.3	51.0
48–67	49.0	—	60.0
68–99	—	—	62.7
100 or more	—	—	75.0

Source: ACS survey

Data from the ACS survey permit a rough calculation of the value of a Ph.D. degree. Assume that a chemist works in industry, that he earns the median salary for his level of experience, that median salaries rise generally in step with inflation (they have not done that well recently, but rose more rapidly throughout the 1960's), and that he retires at 65. If he starts working immediately after graduating with a B.S. degree, he will earn (in constant 1980 dollars) about $1.2 million during his career.

If, on the other hand, he spends four years studying for a Ph.D. before getting an industrial job, his earnings will total nearly $1.5 million. Thus, exclusive of any added fringe benefits he may accumulate, his investment of time and effort in a Ph.D. will earn him $250,000 to $300,000 more than his compatriot with a B.S.

The ACS Office of Manpower Studies will publish a full report on its 1980 survey, with more detailed data on the employment status and salaries of ACS members, next month. The complete report, "Salaries 1980," can be purchased from Special Issues Sales, American Chemical Society, 1155—16th St., N.W., Washington, D.C. 20036. The price of the report is $25 a copy. □

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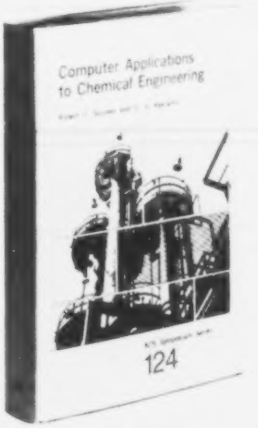

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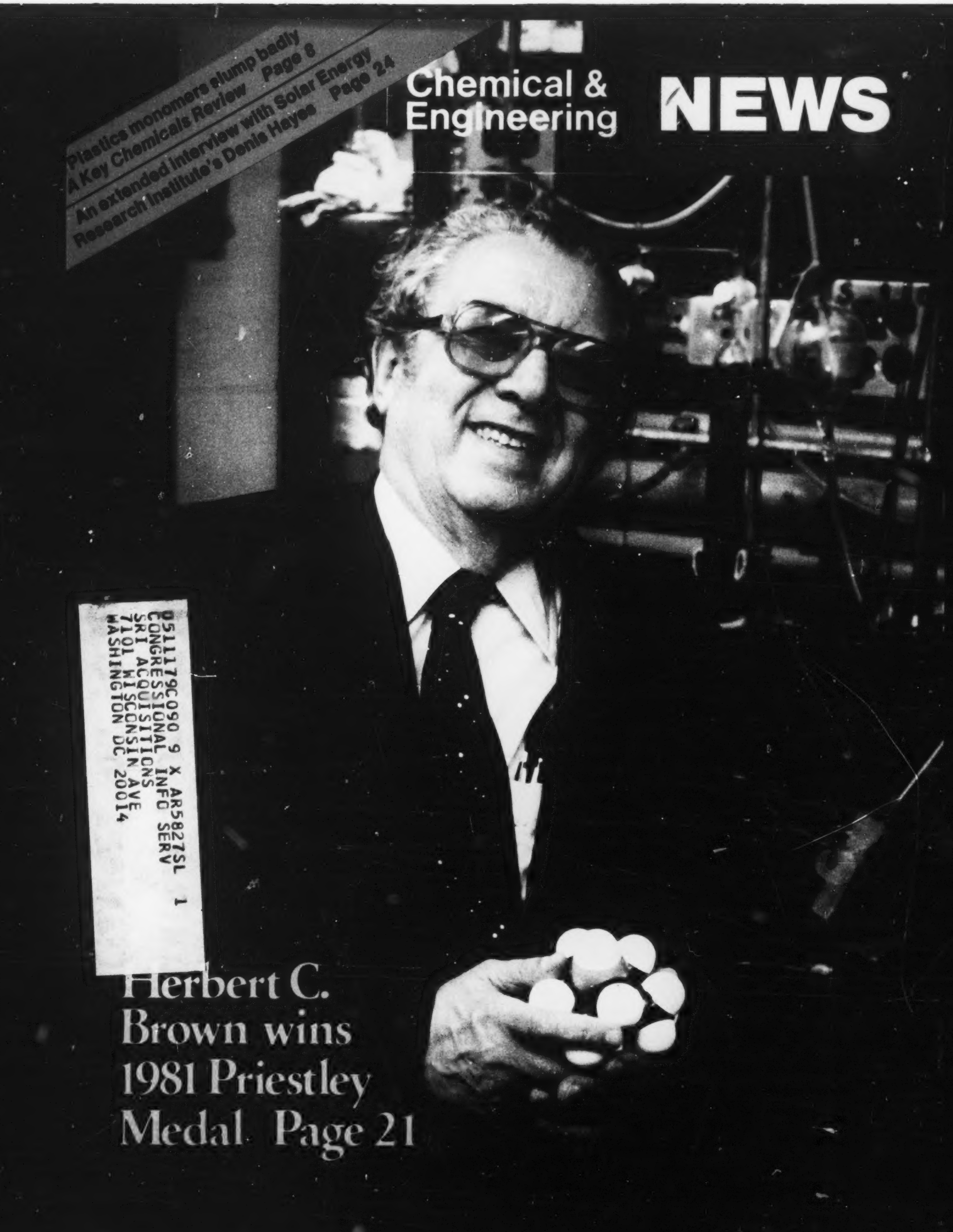

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Market sags for plastics monomers

Trouble in plastics market has worked its way back to major monomers—vinyl chloride, styrene, propylene oxide—which are reeling

Is 1980 going to be a repeat of the 1975 debacle for vinyl chloride, styrene, propylene oxide, and other U.S. plastics monomers?

At this point in the current recession, industry sources report monomer sales declines that suggest ominously that another crunch could well be in the making for this multibillion-dollar part of the U.S. chemical industry. Combined production value for vinyl chloride, styrene, and propylene oxide—whose outlooks are detailed on the following pages—will be about $4.4 billion in 1980.

So far, the situation has an important time difference from what happened in 1975. Last time, the slump in production began in late 1974 and took its full toll during 1975. In 1980, however, production of these chemicals held up during the first quarter.

However, after some faint warning signs, sales fell off drastically beginning in mid-April and continued down during May and June. The rate of decline appears to have abated in June, possibly because of significant price cuts through temporary voluntary allowances and discounts. For example, about the worst case has been temporary voluntary allowances up to 6 cents a lb from 40 cents for styrene plus other less formal discounts of another 5 cents or more.

This supposed help from price cutting may not last. Lower prices, of course, help shift inventories downstream as consumers gamble that such cuts will not be repeated and as they try to "average down" costs. But if the inventory pipeline backs up after a few months because end market sales continue to fall, price cutting will do little to raise overall monomer production.

In fact, on the Gulf Coast, there are no takers at all for some spot-market monomer even at ridiculously low prices. This lack of volume makes it hard to judge the accuracy of spot price rumors.

If sales continue to fall, production will follow and continue low in 1981. In this event, recovery next year may not match 1976, when many major-volume organic chemicals staged dramatic comebacks.

For example, production of vinyl chloride, styrene, and propylene oxide dropped in 1975—25%, 22%, and 13%, respectively, from 1974. However, by 1976, production of each exceeded production in 1974—vinyl chloride 1%, styrene 6%, and propylene oxide 3%.

Now the important questions are whether monomer production will slump as badly this year as in 1975 and recover in 1981 as fast as in 1976. Proposed answers are diverse. Based on early reports of production, 1980 declines may not be so large as those of 1975. However, as consumer goods plant shutdowns are extended and as maintenance and demand-related shutdowns for chemical plants drag on, forecasts for 1980 chemical production are being cut back.

The question of recovery also brings diverse answers. As the recession deepens, the view of a V-shaped recession with a fairly short duration for the slide and rebound gains adherents. But many business people in chemicals don't expect a bottom until early 1981 with a slow recovery lasting throughout the year.

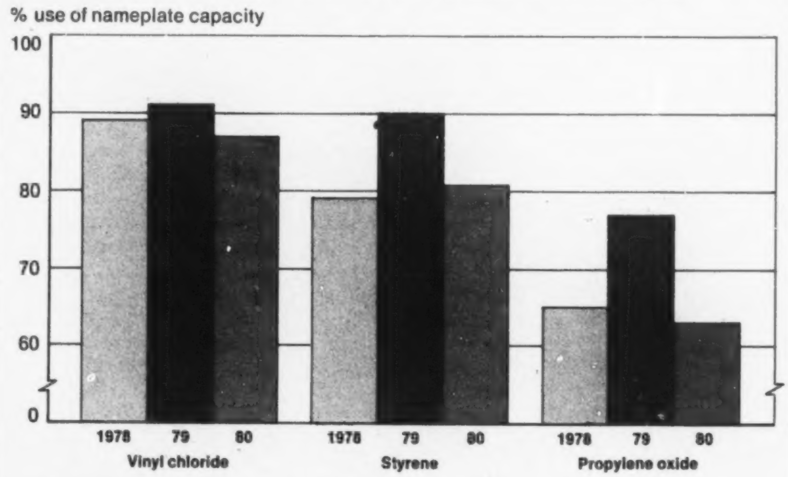
Even with a good recovery next year, some plastics monomers will face overcapacity problems. Capacity expansions are coming for all three monomers covered here in 1980, the most by far for vinyl chloride. If recovery is slower than anticipated and capacity expansions are started up about as scheduled, producers of all three monomers may suffer back-to-back years of low capacity use in 1980 and 1981.

Of the three, vinyl chloride could have the biggest problem. Assuming plans hold up, by 1981 some 2 billion lb per year of new nameplate capacity is expected to be coming on stream to bring vinyl chloride capacity to about 10 billion lb. Strong recovery plus renewed demand growth will be needed to keep operating levels profitable in 1981 and 1982.

Styrene and propylene oxide are in better shape from a new-capacity standpoint. One major unit will be added to the styrene total, and a large debottlenecking will come through this year for propylene oxide. Styrene capacity use could bounce up nicely in 1981, but propylene oxide still will take several years to work off the overcapacity which has plagued it in recent years.

Bruce Greek, Houston

Plant use is well down in 1980 for plastics monomers



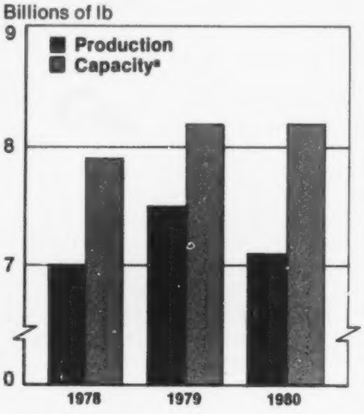
Sources: Producers and C&EN estimates, International Trade Commission

$CH_2{=}CHCl$

Vinyl chloride

- ***Production slipping***
- ***Capacity bulge due***
- ***Prices softening***

PRODUCTION/CAPACITY



[a] As of first quarter.

HOW MADE

Dehydrochlorination of ethylene dichloride made from ethylene and chlorine

MAJOR DERIVATIVES

Vinyl polymers nearly 100%

MAJOR END USES

Fabricated vinyl plastic items nearly 100%

FOREIGN TRADE

Exports—declining in 1980 about 15% to under 1 billion lb, imports—negligible

PRICES

Contract 22 cents a lb; discounting growing

COMMERCIAL VALUE

$1.5 billion for total production, 1980

A sales decline in polyvinyl chloride (PVC) is worrying U.S. producers of the monomer, vinyl chloride. All hopes of exceeding 1979 monomer production of 7.5 billion lb appear gone, even after a first-quarter 1980 production rate of more than 7.7 billion lb on an annualized basis.

Quite a range of estimates exists for 1980 vinyl chloride production as producers try to evaluate the impact of the recession on their operations. The estimate spread, however, is relatively less than for many other organic chemicals. Vinyl chloride output estimates range from 6.5 billion to 7.5 billion lb. The high end of estimates, matching 1979 production, comes from optimists who expect pipe and other PVC extrusions to provide some luster for 1980. A consensus would put vinyl chloride production down about 5% from 1979 at about 7.1 billion lb.

If production holds up this well, producers will have to run their plants at 86% of first-quarter nameplate capacity of 8.2 billion lb. Considering the technical constraints on vinyl chloride production, such as emissions control, this operating level indeed would be good. It would just about equal traditional rates and trail more recent rates not too badly.

The operating rate for vinyl chloride plants was much higher early in the year. In fact, the first-quarter production rate of more than 7.7 billion lb per year probably could not be sustained for a year, since it suggests that plants run at 95% of capacity, extremely high for vinyl chloride.

A lot of new vinyl chloride capacity is due later in 1980, about 2 billion lb total at Georgia-Pacific, PPG Industries, and Dow Chemical. But it will not be available for much operation this year because it is scheduled on stream so late in the year. Since current demand for PVC is slowing, the owners of the new production capacity aren't likely to push their construction contractors very hard to complete the plants ahead of schedule.

These new units, of course, concern the industry, as they guarantee overcapacity in 1981 even if vinyl chloride recovers and then returns to historical growth rates. This worry naturally leads to efforts to firm up customers for both existing and new capacity and puts downward pressure on prices, particularly of PVC.

Efforts to raise PVC prices in the face of rising costs weren't successful in the second quarter. In fact, discounting has increased with falling sales. Vinyl chloride also has been hit with some discounting.

About the best that can be said for this bad situation is that price pressure has had the same effect on the raw materials for vinyl chloride—ethylene and chlorine. The reasons for this are the same as for the monomer—new capacity coupled with slowing demand. Ethylene prices, for example, are down nearly 10% for July 1 contract material from the initially announced April 1 contract prices.

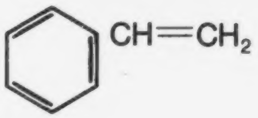
These lower prices will not spur consumption of PVC except in a few special cases. All that lower prices will do is let someone further down the use chain improve profits, one chemical source says discouragingly.

PVC use is growing mainly in various extrusions, now about 60% of the total. Pipe dominates extrusions and probably accounts for more than 40% of PVC use in the U.S. Pipe could be the savior for vinyl chloride production during the recession, say the optimists. Commercial construction, the important type for PVC, apparently is holding up better than are most other kinds of construction. In turn, demand is holding up for PVC pipe, floor coverings, and other fabricated shapes. Strong demand for PVC pipe in agriculture and the like even could result in a net gain for the pipe and fittings outlet in 1980.

However, other uses of PVC will not help PVC and vinyl chloride demand in this recession year. Some uses, such as molded products, may decline. One example is recording disks, whose PVC consumption has gyrated in recent years.

As is the case with many monomers, the dominant use of the polymer will determine the fortunes for the year. For vinyl chloride, that means PVC pipe. Pipe didn't help vinyl chloride in the previous recession in 1975, but some industry sources hope it will this time and give vinyl chloride another above-average year among organic chemicals.

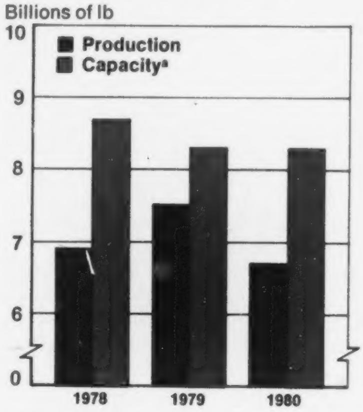
Key Chemicals



Styrene

- ***Demand slumping***
- ***New capacity due***
- ***Prices plummeting***

PRODUCTION/CAPACITY



a As of first quarter.

HOW MADE

Dehydrogenation of ethylbenzene either made from ethylene and benzene or recovered from refinery reformate; coproduction with propylene oxide

MAJOR DERIVATIVES

Polymers 80%, styrene-butadiene rubber 10%

MAJOR END USES

Fabricated plastics 90%

FOREIGN TRADE

Exports—falling to around 750 million lb in 1980, imports—negligible

PRICES

About 35 cents a lb contract at plants

COMMERCIAL VALUE

$2.25 billion for total production, 1980

Some U.S. producers of styrene expect a worse year than hinted by production statistics so far and possibly even worse than suggested by the recession now in full swing. Current business gloom leads to some forecasts of a 20% decline in 1980 styrene production. That means a drop of 1.5 billion lb to about 6 billion lb after 1979's 7.5 billion lb.

Fortunately, other sources see a much smaller decline in 1980 production. More optimistic industry voices put 1980 output at about 7 billion lb, off a half-billion lb, or 7%.

A consensus seems to be about a 10% production decline for styrene to 6.7 billion lb, about the level of 1977. If production does come in at 6.7 billion lb in 1980, the industry's plant operating rate will average a fairly acceptable 81% for the year, excluding new capacity coming on stream now.

A net addition of 600 million lb per year of capacity is coming from American Hoechst. The company has a new plant at Bayport, Tex., with 800 million lb of capacity, and it is shutting down about 200 million lb of capacity at Baton Rouge. However, since startup of the new plant began during the second quarter, the addition will have a potential 1980 output of no more than 400 million lb. Counting partial capacity of the new plant, the industrywide operating rate then would be a bit less than 80% on average for the year. Styrene's first-quarter nameplate capacity was 8.3 billion lb.

Pretty good cases can be made for both higher and lower production of styrene in 1980 than the consensus 6.7 billion lb. These arguments hinge on the effects of high production early in 1980, inventory changes, slumping current sales, loss of markets to olefinics, and the pace of eventual recovery from the recession.

The optimists' case rests mainly on two factors—good production early in 1980 and continued inventory building. During the first quarter, production of styrene topped 2 billion lb, or more than 8 billion lb at an annual rate, according to preliminary estimates of the International Trade Commission. Production then fell 86 million lb in April from March, or roughly 12%. If production for the rest of the year averages a bit less, say off 15%, the total for the remaining quarters of 1980 will be about 5 billion lb. Adding the 2 billion lb from the first quarter brings the total to 7 billion lb for the year.

The pessimists' view is more complicated. It holds that strong production in first-quarter 1980 reflected inventory building at a high rate and not strictly consumption. Far from helping the situation, these inventories will be a burden on production for the rest of the year, driving production rates down to low levels. Much of the inventory building came not from anticipation of styrene demand, but from the desire for a value-added place to put raw material benzene, whose own demand and value in most uses are falling badly.

Sagging styrene outlets are important to the pessimists' view. Exports are down and may continue down, possibly 20% below 1979. In addition, competition from olefinic polymers is slowing growth of polystyrene in major use categories such as packaging and consumer goods. And certainly, the slump in tire production will further reduce styrene use in styrene-butadiene rubber during the year.

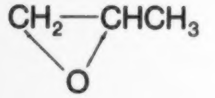
Even the optimists admit that slowing demand for styrene is putting fierce pressure on prices. Big allowances off contract prices are being made, and discounting has increased rapidly in recent weeks, particularly in product for export. From a 40 cent-per-lb list-price peak, styrene's price has hit 31 cents and even lower in spot sales.

The price pressure on styrene also reflects pressure on benzene prices, which are coming way down, more than 15%, in both contract and spot sales. Since benzene represents 85% of the materials cost for styrene, its price greatly influences styrene's price. In turn, benzene's price is directed by crude oil prices and tempered by gasoline demand.

A year ago benzene was putting strong upward pressure on the styrene price. However, this year the benzene price has tumbled from $1.80 per gal to $1.50 on some spot market quotes, and is probably headed still lower.

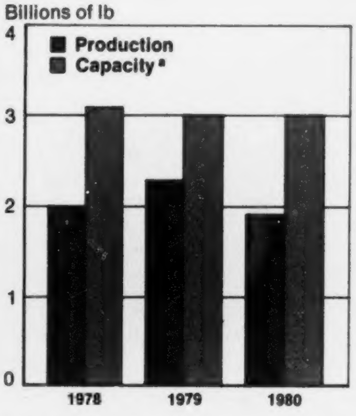
Price pressure and slumping demand certainly will do no good for styrene in 1980. Its short time in the profits sun in 1979 is over, and producers hope the financial night in 1980 will be short.

Key Chemicals



Propylene oxide

- ***Demand well down***
- ***Capacity to drop***
- ***Poor year expected***



[a] As of first quarter.

HOW MADE

Chlorohydration of propylene and subsequent saponification with lime, peroxidation of propylene

MAJOR DERIVATIVES

Polyols 60%, propylene glycol 25%

MAJOR END USES

Polyurethanes 60%, unsaturated thermoset polyesters 10%

FOREIGN TRADE

Exports—falling to about 160 million lb, imports—holding at about 40 million lb

PRICES

Contract at plant 35 cents a lb; no spot market

COMMERCIAL VALUE

$650 million for total production, 1980

1980 will bring more changes for propylene oxide than just a widely forecast decline in production. Two small producers will drop out, leaving only Dow Chemical and Oxirane.

As of midyear, both BASF Wyandotte and Olin will phase out production of propylene oxide—BASF Wyandotte at Wyandotte, Mich., and Olin at Brandenburg, Ky. Combined capacity to be eliminated is about 300 million lb a year, or a bit more than 10% of total U.S. capacity. Both plants are relatively old and used dated chlorohydrin technology, which is beset with pollution problems and inefficiencies when operated on a small scale.

However, both companies indicate they will continue to make propylene oxide derivatives. They thus will increase outside purchase of the material and swell propylene oxide's merchant market. As a result, the two shutdowns will not appreciably affect demand for propylene oxide except in minor adjustments due to inventory changes.

The decline in propylene oxide production this year will come mainly from reduced demand for derivative polyols in polyurethane plastics. The decline is expected to be 15 to 20% of 1979 production of 2.3 billion lb, or to about 1.9 billion lb.

Although some industry sources forecast even lower 1980 production for propylene oxide, 1.9 billion lb still would sink the average plant operating rate to less than 65% of first-quarter nameplate capacity. The actual average rate would be closer to 69%, because of plant shutdowns coming up.

With little likelihood of major new capacity anytime soon, capacity use for propylene oxide can only go up after the recession. But the rate rise will be slow because growth forecasts over the next few years are in the 4 to 5% area. Oxirane will tack on 100 million lb to capacity at the end of 1980 through debottlenecking. After that, the new-capacity slate is blank.

The big problem for propylene oxide this year is the same as for many major-volume chemicals—steep declines in auto and home markets. These two consumer outlets account for much of polyurethane use and so govern the fortunes of propylene oxide.

Even before the slump in auto sales, polyurethane flexible foam used in seats was threatened as designers worked to reduce the auto weight to try to meet mileage standards. The combination of weight savings and lower auto volume could bring a 30% decline in the amount of propylene oxide going into auto seating this year.

Offsetting this decline is increased use per auto of reaction injection molding (RIM) of rigid polyurethane components. Other RIM polyurethane products also are being developed, resulting in large growth. On balance, RIM consumption of propylene oxide in 1980 may show a slight increase, the only category that forecasters figure this way.

Other flexible foam uses depend heavily on the housing market. Furniture, especially bedding, and carpets continue as big uses. New-housing declines hurt but are partially offset by refurbishing of existing houses as consumers attempt to live with what they have.

Propylene glycol, the second largest use of propylene oxide, goes mainly into unsaturated thermoset polyester resins and into additives for a host of materials. Throughout 1980, polyester resins have been reeling under the impact of the recession on their dominant outlet, glass-fiber-reinforced plastics. These plastics go heavily into consumer durables such as autos, boats, and appliances.

The reinforced plastics market began to soften much earlier in the economic downturn than did most of the rest of the chemical business. The reason is reinforced plastics' close tie to long suffering auto and boat markets. By early 1980, reinforced plastics producers knew they faced a falling year.

The decline in these applications could translate to a 20% decline in this area for propylene oxide. Propylene oxide use in food, drugs, and cosmetics, though small, probably will hold about even in 1980.

Overall, because of its recession-socked uses, propylene oxide probably will have a greater decline in production than will many other chemicals in 1980. Its production could fall off more than in the 1974–75 recession, a prospect of little comfort to producers who have just trudged through a long business expansion with overbuilt plants.

Weaknesses developing in European chemicals

Executives and chartists in the West European chemical industry are paying closer attention than usual to economic data. And the trends they see emerging don't please them.

Despite strong first-quarter sales and pretax earnings that most chemical companies in Western Europe achieved this year, there are definite signs of weaknesses developing. Demand has slackened and plant capacity utilization has slipped as a result.

The situation shows every sign of worsening. Business is slack in Europe during the summer even at the best of times. This will compound the effect of the current recession as it bites deeper.

Chemical production index statistics graphically illustrate the situation. In France, January saw the index almost reach 172 (1970 = 100), an all-time high for the country. But in February it fell back to about 169 and moved down further to below 162 in March. The official April figure wasn't out at press time, but it's expected to be bad.

The situation is similar in the U.K. The chemical production index plateaued at about 143 in January and February and then retreated below 134, the level last registered in March 1978. (The deep trough in January last year was due to a prolonged strike by U.K. road haulage drivers at the time.) The result was a decline of nearly 7% between January and April this year, compared to a rise of some 22% in the first four months last year.

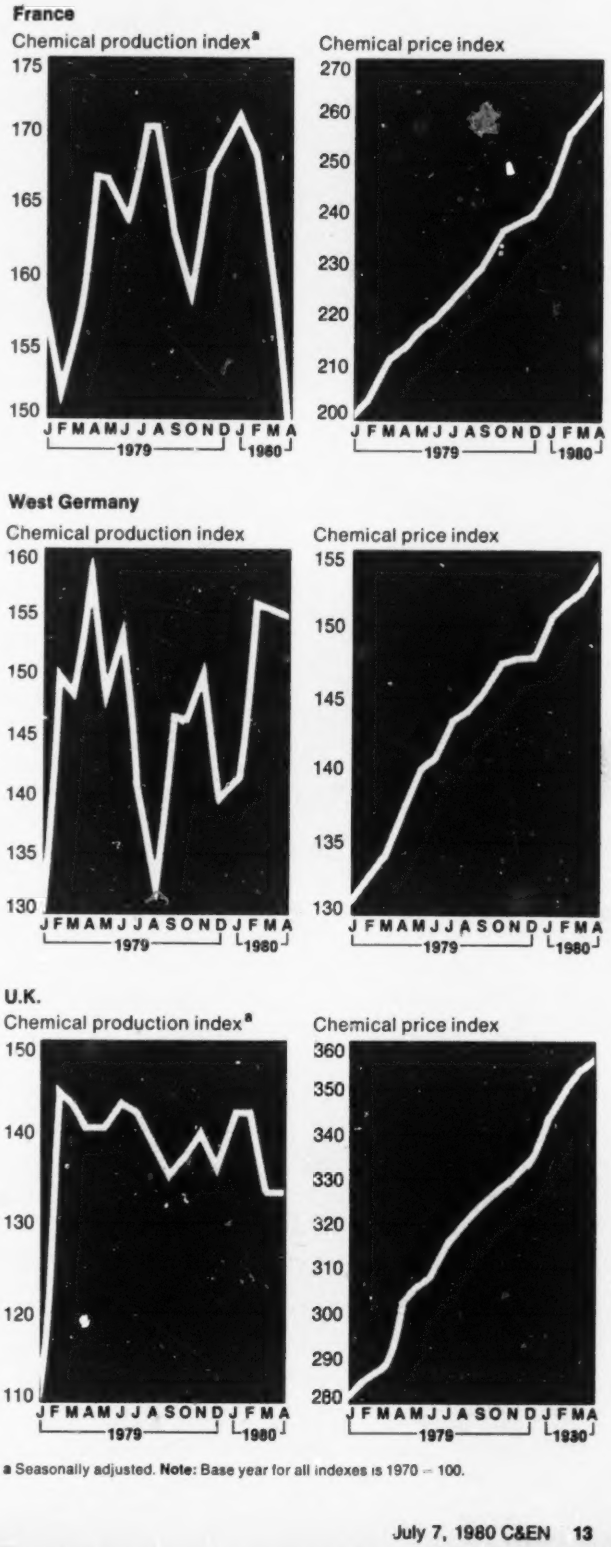
West Germany bucked the trend, but only barely. March and April were off from the February high. The first four months showed an overall production increase of about 9%. However, this was only half the value of the rise in the first four months of 1979.

Fortunately, the chemical price indexes in the three countries have continued upward, although chemical managers complain that what gains they have been able to achieve have not been sufficient to keep pace with rising operation and feedstock costs. Between January and April, chemical prices on average gained 7% in France, less than 3% in West Germany, and about 4% in the U.K.

Matthias Seefelder, chairman of West Germany's BASF, had this to say at his company's annual general meeting recently: "The fact that sales revenue for the month [of June] is higher [than in June 1979] can be ascribed solely to the higher level of prices. It conceals a recession in sales volume indicative of the recession in the market, particularly the [West] German domestic market. The trend in orders received is downward, and policies adopted by our customers signal uncertainty about future movements. It is practically impossible to forecast what the situation will be toward the end of the year."

The statement of Hoechst's chairman, Rolf Sammet, was cast in a similar vein. "Reduced [sales] and shrinking margins for agrochemicals, organic chemicals, plastics, and fibers are clear indicators of a trend reversal," he says. "We need, therefore, to be rather more circumspect with our forecasts for the remainder of the year without, however, becoming pessimistic."

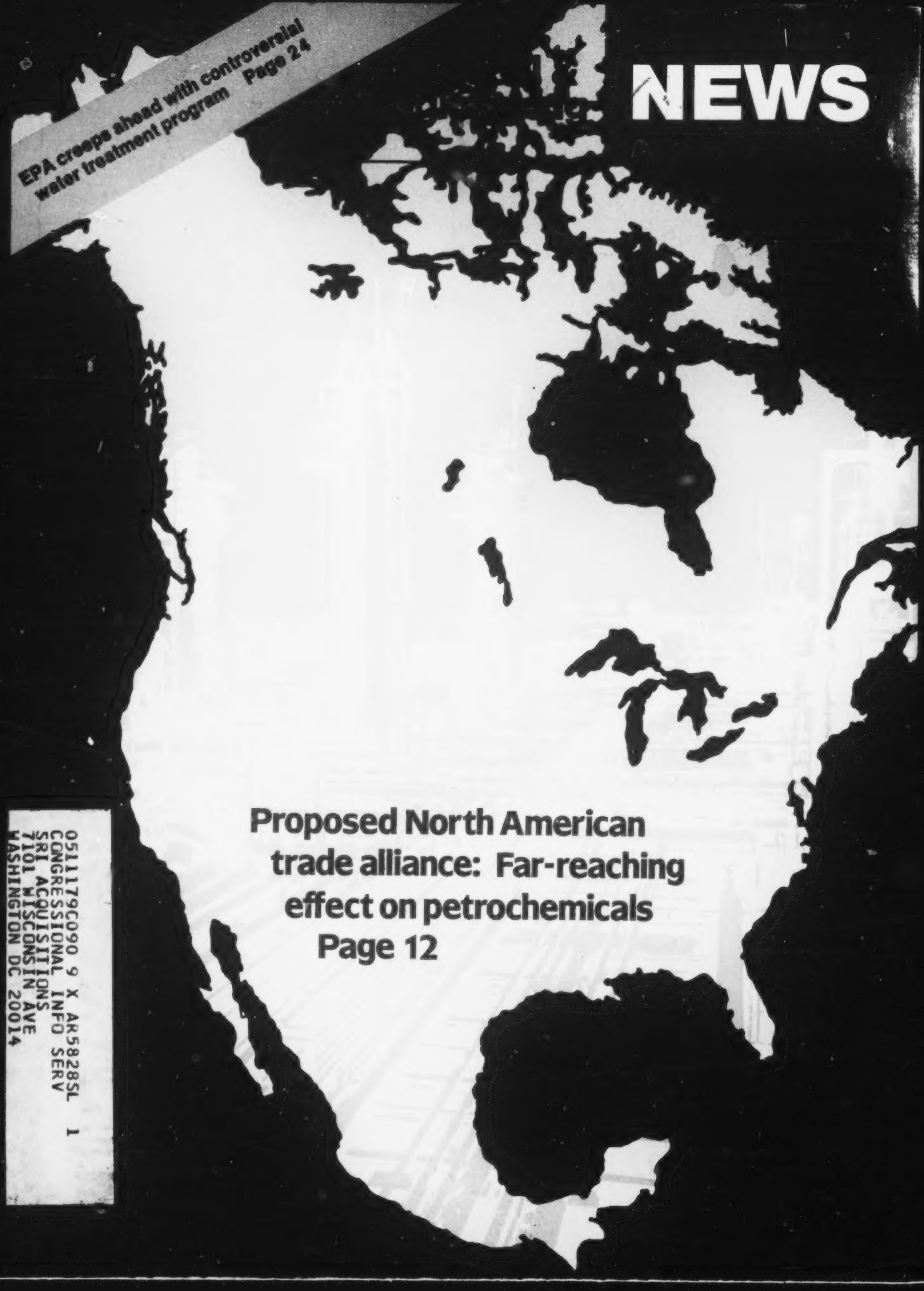
Dermot O'Sullivan, London



a Seasonally adjusted. **Note:** Base year for all indexes is 1970 = 100.

NEWS

EPA creeps ahead with controversial water treatment program Page 24



Proposed North American trade alliance: Far-reaching effect on petrochemicals

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Tire industry changing in face of problems

Slumping sales, changes in tire technology and car markets are forcing industry to diversify, close plants, and change tire product mix

William J. Storck
C&EN, New York

It is hardly any surprise, considering the state of the automobile industry, that the tire industry also is in trouble.

Last year shipments of passenger tires in the U.S. dropped 10.3% from 1978 to 174 million. Tires made for the replacement market fell 9.8% to 122 million, and original equipment tires (those made for new cars) fell 12.4% to 48 million. In fact, total shipments of passenger tires last year dropped below 1974 levels, when about 175 million passenger tires were shipped. Passenger tires account for about 80% of all tire shipments in the U.S.

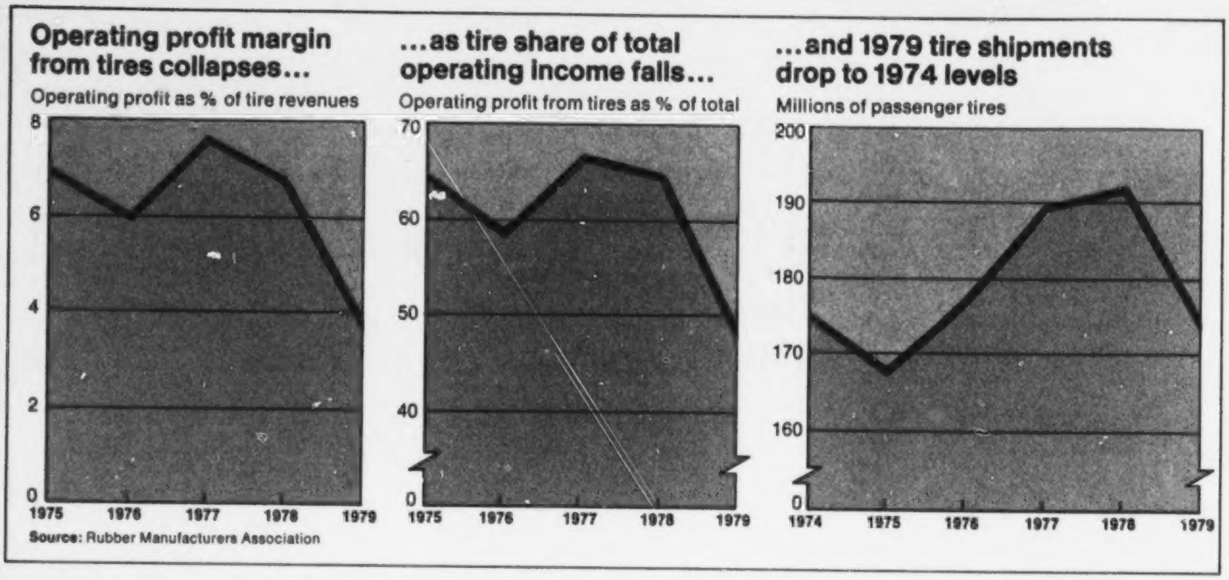
The picture thus far for 1980 is even more dismal. Through April total shipments of passenger tires were off 22.8% from the first four months of 1979 to 46.8 million. Replacement tire shipments fell 20.5% to 32.2 million, and original equipment tire shipments plummeted 29.5% to 13.2 million from levels of the first four months of 1979. These figures are based on statistics published by the Rubber Manufacturers Association.

In 1979 combined sales from tires and related products from the five largest U.S. tire makers—Goodyear, Firestone, Uniroyal, B. F. Goodrich, and General Tire—climbed 5.2% to $14.7 billion from 1978. However, operating profits from tires and related products from the same five companies fell 42.6% to a cumulative $542.1 million in 1979 from the year before. Operating profit is computed by subtracting from sales the cost of goods sold, the cost of selling, and administrative expenses.

This year, the dramatic downturn in the tire market has forced a number of layoffs and plant closings—mostly at bias-ply tire plants. It has caused a $13.8 million loss at Firestone in its second fiscal quarter and a $12 million loss at Uniroyal in its first fiscal quarter. Uniroyal is now projecting a loss for all of 1980. It has forced cuts in benefits at Uniroyal and elimination of cost of living al-

Nontire activities are becoming more important for rubber companies

Company	Nontire sales as % of total		Nontire operating profit as % of total		1979 nontire activities
	1979	1975	1979	1975	
Goodyear	18.7%	17.3%	30.0%	25.8%	Industrial rubber—Hose and belting products; tank tracks Chemicals—organic chemicals; polyester resins
Firestone	27.5	18.9	51.6	34.0	Diversified products—automotive hose; molded, extruded, and calendered rubber components for transportation; steel rims and wheels; stainless steel beverage containers; beer kegs; seat belts and passive restraints Chemicals—Flexible urethane foam; polyvinyl chloride resin; vinyl films and sheeting; synthetic rubber; nylon and polyester yarns; nylon resins
Uniroyal	47.2	42.7	144.8	[illegible]	Chemicals—rubber chemicals; specialty chemicals; pesticides and plant growth regulants; synthetic rubbers; plastics; blowing agents Fabricated rubber & plastic products—plastic-coated fabrics; thermoplastic acrylonitrile-butadiene-styrene sheet; fabricated plastic parts; foam rubber; industrial, automotive, and hydraulic hose; conveyor and power transmission belting; expansion joints; industrial adhesives; industrial fabrics; shipping containers Leisure, sport, and other products—industrial clothing; waterproof footwear; sound and thermal insulation
B. F. Goodrich	55.5	46.9	73.7	59.6	Chemicals—polyvinyl chloride resins; caustic soda; chlorine; specialty polymers; plastic additives; vinyl, nitrile, and acrylic latexes Engineered products—caulks, sealants, and adhesives; roofing materials; industrial rubber products; transportation products; conveying systems; fabricated and elastomeric products
General Tire	53.7	53.7	69.1	65.1	Chemicals and plastics—glass-fiber-reinforced plastic; vinyl-coated fabrics; vinyl wall coverings; synthetic rubber; adhesives; latex; polyvinyl chloride resin; vinyl foams and films Industrial products—engineered rubber and plastic parts; extruded sponge; beltstrip and vinyl seals; industrial hose; automotive parts; insulation for rockets and missiles; bridge expansion joints; railway crossing units Aerojet General—Goods and services for energy, environmental protection, agriculture, defense, aerospace, and industrial plant modernization RKO General—radio and television broadcasting; soft drink bottling; motion picture theaters; airline transportation; cable television



Operating profit margin from tires collapses...

Operating profit as % of tire revenues

...as tire share of total operating income falls...

Operating profit from tires as % of total

...and 1979 tire shipments drop to 1974 levels

Millions of passenger tires

Source: Rubber Manufacturers Association

lowances at Firestone (C&EN, July 7, page 6). And it has caused industry observers to wonder about the future of the U.S. tire industry in general.

The downturn in tires is having its effect on more basic products within the chemical industry. For instance, production of carbon black, which is used to strengthen rubber, fell 0.6% in 1979 from 1978 levels and production of styrene-butadiene rubber fell 1.2% last year.

Although the slump in the auto industry has had its effect on tires, the problem is really deeper than that. It seems just as much characterized by downsizing of autos, foreign car imports, and technological advances in the tire industry itself.

Smaller cars from Detroit are creating a number of problems for tire producers. One is that tires on the smaller cars last longer than they did on the dreadnoughts of Detroit that were the predominant product just a few years ago. This then cuts into the replacement tire market. Also, the markup on smaller tires is not so great as for bigger tires. Thus, even if the same number of tires are sold, the return on them is smaller.

Technological advances in tires are spelling another problem for tire makers. The switch from the older bias-ply tires to radial tires has extended tire life considerably. In one sense, tire makers have been too smart for their own good. At one time, a car was expected to go through an average of 4.5 sets of tires in its lifetime, but now it is expected to use only 2.5 sets.

Other advances eventually may have an effect. One of these is the self-sealing tire, which seals itself against punctures. If the trend toward this type of tire continues, it eventually may lead to the elimination of the spare tire. This, in turn, would cut tire sales 20%.

Foreign competition in automobiles also is making itself felt in the tire industry. Each car that is built abroad is equipped with tires that are manufactured abroad, thus cutting into the original equipment market for U.S. tires.

There is one other big problem that tire makers have been coping with for years—the parsimony of the auto companies. Tire makers have long complained that they do not get a decent return on their sales to Detroit. However, they have buckled under to the price pressure put on them by the auto makers because the prevailing wisdom has been that the buyer of a car is likely to replace the tires with the same brand that were supplied with it originally. And manufacturers get a better return on replacement tires.

Although this argument may be true—and it has more than its share of naysayers—tire companies admit that they have been making little, or actually losing, money on their sales to Detroit. Compounding this situation, tire makers say, is that supply contracts between tire companies and auto companies are patently in the car makers' favor. The contract price is negotiated before the model year and that price prevails for the entire model year regardless of cost increases to the tire companies. There is no escalator clause or reopener. Thus, in times of rapidly rising raw material costs, by the end of the model year a tire maker can be losing money on every tire sold as original equipment.

Tire companies have taken several steps to combat these problems. The first step was diversification. This has been very successful in many of the companies. Divisions other than tires and related products now account for about 57% of sales at Goodrich and 54% of sales at General Tire. Other tire makers have followed suit, but not to so large an extent. However, the moves to diversification were designed more to offset the cyclical nature of the tire markets, and are largely unsuccessful in bucking up profits when the market changes as it has in the past few years. In fact, the diversification efforts have just put a gloss on a bad apple.

More to the point are efforts by the companies to standardize tire sizes and styles, thus reducing the number of different types of tires that they must supply both to the auto makers and to the replacement market. Tire makers see standardization as a move to more simplicity, a method of reducing working capital requirements, and a need for maintaining fewer tires in inventory.

Then, too, tire manufacturers are seeking ways to get higher returns on the smaller tires they are selling. One possibility takes a cue from the auto industry: it is to add options, such as self-sealing capability, to the tires. In this way tire makers hope to be able to charge more, thus increasing their margins.

Producers also are getting out of bias tire manufacture and concentrating on radial production. They also are shifting the base of manufacturing to more profitable plants.

In addition, producers say they are going to have to break, or at least compromise on, the pricing structure in Detroit. They say that they must be able to get a satisfactory return on what they sell as original equipment. However, with the problems at two of the auto companies—Ford and Chrysler—this may not be easy. ☐

North American trade alliance gains support

A broad trade alliance among the U.S., Canada, and Mexico isn't likely yet, but pacts for specific industrial sectors may be possible; one candidate for agreement is petrochemicals and the effects would be profound

Earl V. Anderson
C&EN, New York

The U.S. chemical industry is marshaling its trade expertise, as it has done so many times before, to confront yet another major international trade issue. It's not a new issue; Henry Clay snorted about it in his day, and it has resurfaced briefly several times since then. But it is surfacing now in a way that casts a new sense of urgency upon it and makes it impossible to ignore.

The idea, now gaining wide and influential support, is the formation of some sort of North American trade alliance. Conceptually, this alliance, or trade "arrangement," would bind the U.S., Canada, and Mexico into a still-vaguely-defined trilateral trade pact that would benefit all three countries.

Myron T. Foveaux, the Chemical Manufacturers Association's legislative representative for international trade and economics, calls it "a tremendous international issue."

As with most international issues that are "tremendous," things don't happen fast. But the groundwork is being laid now. Repercussions from this trade arrangement would not be felt for at least five years, and possibly no sooner than 15 years. But repercussions there are bound to be, if an agreement is reached, particularly for the petrochemical industry.

Within the broad concept of a North American trade alliance lie all sorts of options. The most obvious, and the ones that receive the most publicity, are a customs union and a free trade area.

A customs union, or common market such as the European Economic Community, involves free movement of goods, labor, and capital among members. There is a common external tariff against the rest of the world. A customs union implies a certain degree of political cooperation.

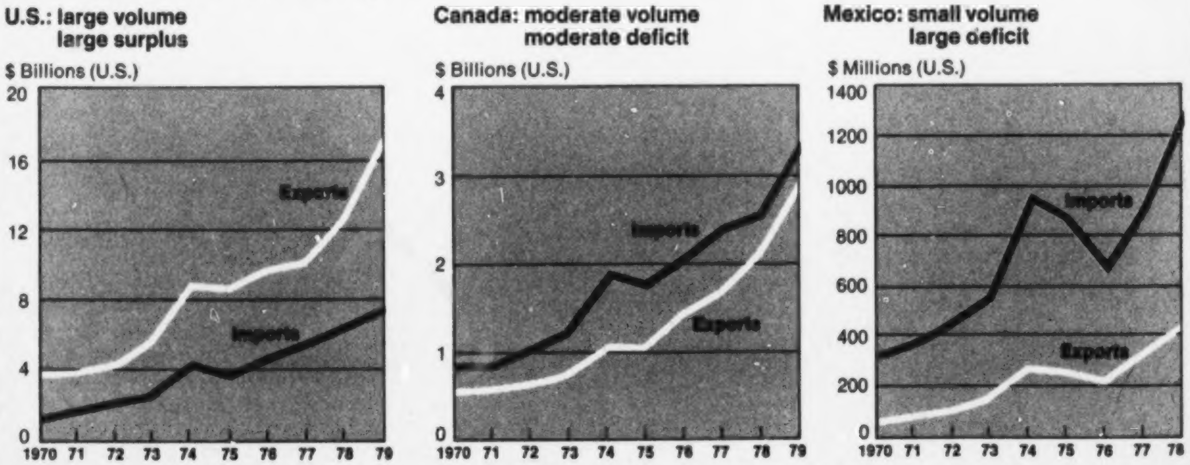
In a free trade area such as the now-weakened European Free Trade Association, there is only duty-free trade among members. There is no free movement of capital and labor, nor a common external tariff.

There's almost universal agreement that it would be extremely difficult to consummate an all-encompassing trade pact such as this among the three North American neighbors. It's tough enough to do when countries are economic equals. That's hardly the case with the U.S., Canada, and Mexico.

But there are other possibilities. If a broadly based trilateral arrangement is beyond reach, perhaps a broadly based bilateral pact could be negotiated. It could bind the U.S. with Canada or with Mexico.

Still another approach getting serious attention now is sectoral agreements. This is where petrochemicals come in. The thinking goes that if a full deck is too difficult to handle, why not work with a few cards at a time? Why not select a few industrial sectors or product groups that can be wrapped into a smaller but easier-to-handle trade package? To many of the experts working on the problem, this is a possible, and more sensible, first step toward a more all-inclusive trade deal.

How chemical trade stacks up



Sources: U.S. Census Bureau, Organization for Economic Cooperation & Development, Statistics Canada, Asociación Nacional de la Industria Quimica

Besides, there is a precedent for the sectoral approach. The U.S. and Canada signed such an agreement covering automobiles and parts in 1965.

The problem is that not many industries lend themselves to sectoral treatment in a North American trade alliance. One that does, however, is petrochemicals. Agriculture and energy are other possibilities, but among manufacturing industries, petrochemicals stand out as a leading contender.

Some of the reasons are obvious. Petrochemical trade is one area in which all three countries share an intense interest. Last year the U.S. staggered under the weight of a $25 billion balance of trade deficit, but its chemical industry generated a $10 billion trade surplus. About two thirds of U.S. chemical exports are petrochemicals.

Both Canada and Mexico want to upgrade more of their extensive hydrocarbon resources into petrochemicals. With its small domestic market of only 23 million people, Canada has to win more export markets to justify the world-scale plants it must have to be a competitive petrochemical producer.

Mexico has big petrochemical ambitions. Its first goal is to build enough capacity to satisfy internal demand and reduce its petrochemical imports. Beyond that, however, Mexico also has its eye on export markets.

For both Canada and Mexico, the U.S. sits in the middle as the most logical export target. It also happens to be the world's largest consumer of petrochemicals.

Actually, both Canada and Mexico already claim the U.S. as their leading chemical trade partner. About 85% of Canada's chemical exports go to the U.S. and a hefty 68% of its chemical imports come from the U.S.

Mexico's chemical trade is almost as dependent upon the U.S. as is Canada's. About 45% of Mexico's chemical exports find a market in the U.S., and the U.S. supplies more than half of Mexico's chemical imports.

U.S. chemical trade, on the other hand, is more diversified and not so dependent on its northern and southern neighbors. Only 5% of U.S. chemical exports go to Mexico and only 3% of its chemical imports come from Mexico. Chemical trade with Canada is more significant. Canada accounts for 14% of U.S. chemical exports and a hefty 28% of U.S. chemical imports.

Little wonder, then, that petrochemicals loom large as a possible sector for trilateral trade negotiations. Yet such a possibility is not widely recognized outside a tight circle of trade experts. The popular conception of a North American trade alliance still is that of a free trade area or customs union.

Oreffice: time has come

Whatever the form, support for an alliance is growing, not so much yet in Mexico, but definitely in the U.S. and Canada. Presidential hopeful Ronald Reagan, former hopeful John Connally, and California governor Jerry Brown are among prominent politicians who have endorsed the concept. Dow Chemical president Paul F. Oreffice says that he is convinced "the time has come for Canada, Mexico, and the U.S. to form some sort of economic union."

Cynics still have good reason to ridicule the idea. There are a multitude of problems. Some are economic; many are political; and not the least of them are psychological. Nationalism is a strong force in the minds of many Canadians and Mexicans, especially concerning dealings with the U.S.

Baucus: spearheaded Senate caucus

Cynicism alone, however, won't kill the idea of strengthening trade ties in North America. It is attracting more attention and support now than it ever has before.

One reason is the proliferation of regional economic blocs throughout the world. Many are adopting an "if you can't lick 'em, join 'em" attitude. They believe that the best way to survive in this age of regionalism is for the three North American countries to form their own regional bloc.

Then there is energy. Mexico and Canada have huge resources and figure to accumulate more. The U.S. has a mighty thirst for energy products. Some believe that a satisfactory North American alliance can be worked out hinged primarily to energy. Dow's Oreffice, for instance, made his proposal for a North American economic union in a speech entitled "Energy—Key to a North American Alliance."

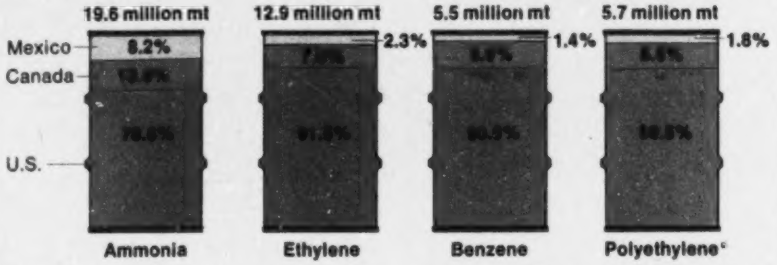
But the very word "energy" is a red flag to many Canadians and Mexicans. They rebel at the thought of sacrificing their precious energy resources on the altar of U.S. materialism with little, as they perceive it, in return.

Despite the odds against ever creating a North American trade alliance, the U.S. chemical industry isn't taking the issue lightly. CMA's Foveaux says: "The amount of time we are going to invest in this indicates how important we think it is."

CMA has formed a task group to study the ramifications of a North American trade pact in whatever form it may emerge. Chaired by Max Turnipseed, Ethyl Corp.'s manager of international trade affairs, the group has about a half-dozen members and Turnipseed hopes to recruit more.

Next week, the chief executive officers of several U.S. chemical companies will be among those attending a brainstorming session called by the recently formed Senate Caucus on North American Trade. Sen. Max Baucus (D.-Mont.) spearheaded efforts to create the caucus. Last year, he chaired Senate hearings on North American economic interdependence. Those hearings helped to raise interest in the subject to the level that it is today.

For the chemical industry, that interest will focus initially on a study that the International Trade Commission already has outlined. ITC served notice last month that it was starting an investigation to determine how well the petrochemical industries of the U.S., Canada, and Mexico lend themselves to some kind of freer trade arrangement.



North American petrochemical output is concentrated in U.S.

a High and low density. **Note:** mt = metric tons; percentages may not total 100 because of rounding. **Sources:** U.S. Census Bureau, Organization for Economic Cooperation & Development, Statistics Canada, Asociación Nacional de la Industria Quimica

CMA's task group has only until Oct. 24 to submit written testimony to ITC. There will be no public hearings. Then ITC will have until the end of the year to submit its report to the U.S. Trade Representative.

Although time is short, Turnipseed says that it is too early to speculate about the task group's testimony. He's not certain whether it will recommend a particular course of action or merely respond to the several options that are being considered.

Much will depend upon what the chemical industry's chief executives bring back from their Senate caucus meeting. "That will determine our marching orders," Turnipseed says.

The CMA task group plans to contact petrochemical industry specialists in Mexico and Canada. And it will be busy preparing a full-blown presentation on the subject for CMA's semiannual meeting in Houston this October.

Meanwhile, task group members will be busy interacting with several government agencies. They plan to meet with ITC and directly with the U.S. Trade Representative. Other agencies have been phoning CMA with requests for information.

These phone calls reflect an interest in North American trade that's spread throughout the entire federal government. That's not surprising. In the Trade Agreements Act of 1979, Congress directed the President to make a study of possible new trade ties with Canada and Mexico. He has until July 26, 1981, to report back to Congress.

Inevitably, an interagency task force has been formed, which is chaired by the Trade Representative. Harvey E. Bale, deputy director for policy development for the office of the U.S. Trade Representative, who heads up the office's North American trade effort, says that the Administration is interpreting its Congressional mandate broadly. "It's not just a question of a free trade area or a customs union," he says.

Initial efforts to improve trade relations with Canada and/or Mexico could start with much more modest steps. One possibility is simply to inaugurate better consultation procedures on regional problems.

In a sense, this already is being done. Governors of several New England states have met with their counterparts from Canadian maritime provinces. And recently, governors from both sides of the Mexican-U.S. border met for the first time.

Then there's the sectoral approach. Bale warns against placing too much emphasis on petrochemicals. There are other possibilities, he says. The Department of Agriculture is looking into agricultural trade prospects and the Department of Energy is handling energy relationships.

Meanwhile, the interagency task force is conducting a "broad review" of manufacturing industries. Electronics and autos will get a particularly close look.

Despite Bale's caveat, there's little doubt that, among manufacturing industries, petrochemicals rate as a best bet for any future North American trade deal. In fact, petrochemicals probably would have warranted serious consideration even if Congress hadn't directed the President to make a study.

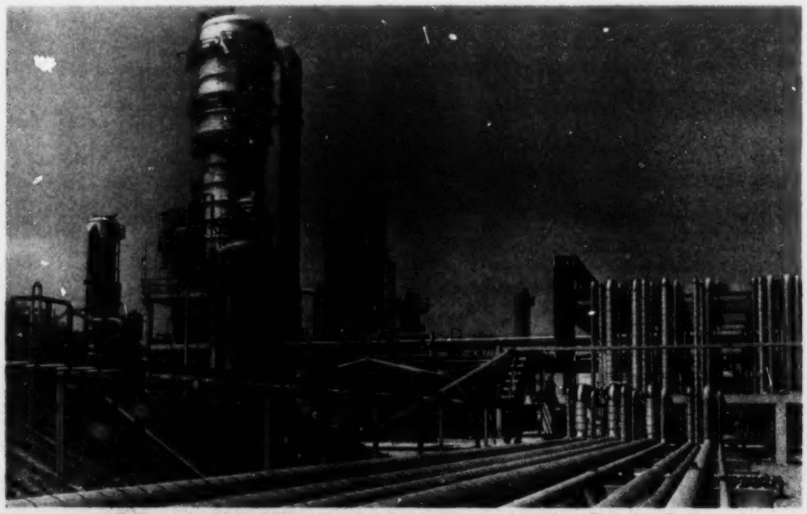
From a Canadian point of view, at least, petrochemicals are an unfinished piece of business, a leftover from the Tokyo round of multilateral trade negotiations. And at last year's hearings conducted by Sen. Baucus on economic interdependence, Dow Chemical of Canada executives came up with a proposal that is too explosive to ignore.

During the multilateral trade negotiations, Canada and the U.S. made a serious attempt to negotiate a bilateral trade agreement. Petrochemicals figured prominently in the discussions. The petrochemical impetus came from Alberta Premier Peter Lougheed. With the petrochemical action moving from traditional chemical centers in Montreal and Sarnia to gas-rich Alberta, Lougheed proposed that Canada seek freer access to U.S. markets for its petrochemicals in return for a promise of increased gas exports to its energy-importing southern neighbor.

Later, this same theme was echoed in a Canadian chemical industry task force report to the Canadian government. The task force made 34 specific recommendations. One of them was that the Canadian government negotiate a bilateral free-trade agreement with the U.S. for a specific list of petrochemicals.

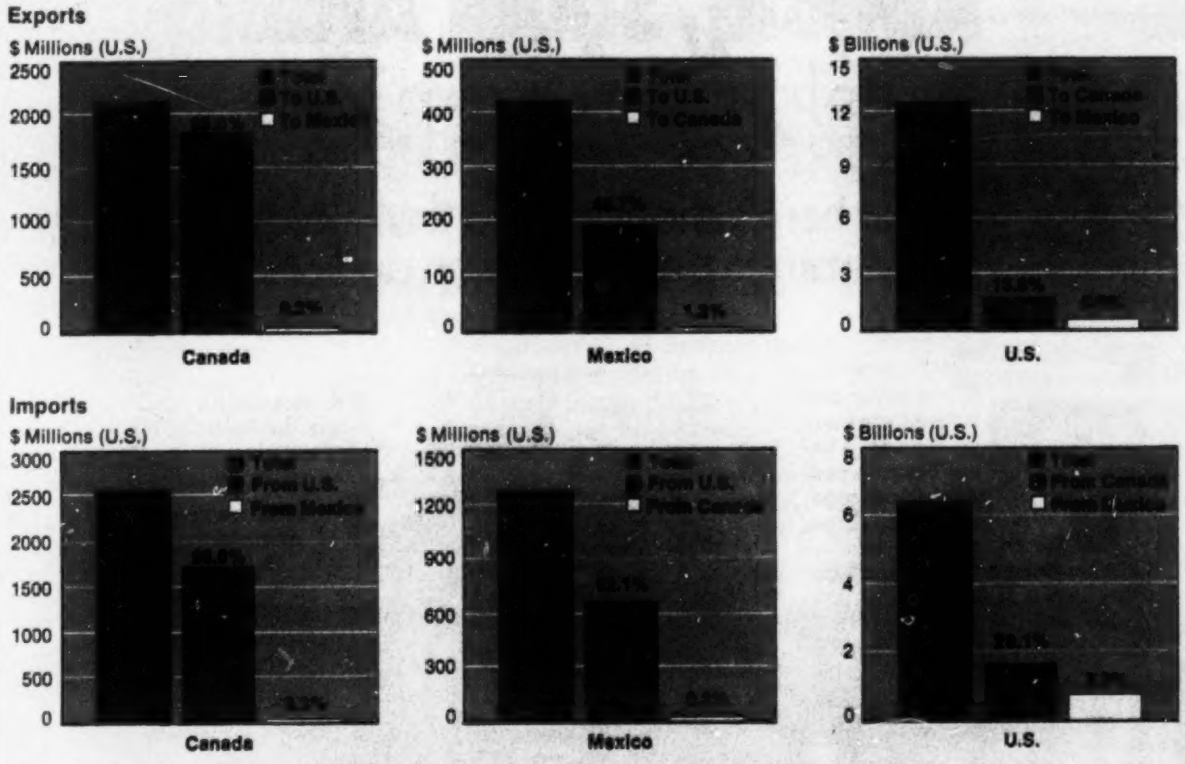
This list included ethylene oxide, ethylene glycol, ethylene dichloride, methanol, high- and low-density polyethylene, polyvinyl chloride, propylene tetramer, styrene, and vinyl chloride. Understandably, these products are the ones that the Canadian chemical industry is emphasizing in its petrochemical buildup.

During the trade negotiations, U.S. and Canadian negotiators were unable to reach agreement on a bilateral



Polysar's 600 million lb-per-year styrene plant at Sarnia, Ont.

Canadian, Mexican chemical trade depends heavily on U.S.



Note: Data are for 1978. Sources: U.S. Census Bureau, Organization for Economic Cooperation & Development, Statistics Canada, Asociación de la Industria Quimica

pact. In the Tokyo round, all tariff concessions were made on a multilateral basis.

Of course, Canadian petrochemical producers can take advantage of the multilateral tariff cuts that the U.S. made on chemicals. However, Canadian chemical companies are bitterly disappointed in the U.S. tariff offers on petrochemicals.

In its analysis of trade negotiation results, the Canadian Chemical Producers' Association notes that, for many important inorganic chemicals, tariffs will be eliminated completely in Canada and the U.S. Those tariffs were low to start with, however, and the association expects only moderate expansion of two-way trade in inorganics.

The U.S. made significant tariff cuts on specialty chemicals, whereas Canada's reductions were minor. Canadian producers see little benefit, however, because the Canadian specialty chemical industry sells primarily to its own domestic market in the face of intense import competition. It exports very little and doesn't expect to improve its export performance in the future.

For Canada, the big disappointment was the extent of U.S. petrochemical tariff concessions. It did not receive what it had hoped for or what it expected. During the final days of the multilateral trade negotiations, the U.S. and the European Economic Community withdrew many of their petrochemical tariff offers because they were under pressure from their domestic industries. And Canadians argue that, as a result of the way in which the U.S. converted its tariff rates to eliminate American Selling Price, Canada will end up facing higher tariffs on many key petrochemicals than it would have without a Tokyo round.

Little wonder, then, that U.S. petrochemical tariffs are still very much on the minds of Canadian chemical executives. Any doubts about that were erased when Robert E. Naegele (then Dow Chemical of Canada president) and company vice president Clifford L. Mort came to Washington, D.C., to testify at last year's Senate hearings. They brought with them a refinement of the proposal originally made by Alberta's Premier Lougheed.

In the no-nonsense manner that is his trademark, Naegele got right to the heart of the energy-trade relationship between the U.S. and Canada. He pointed out that Canada is essentially self-sufficient in energy, figures to add to its extensive reserves of both oil and gas, and will become an even larger exporter of hydrocarbons in the future.

Then Naegele made his U.S. audience sit up and take notice. He said, "Before you take any consolation in what I've said, please understand that the U.S. is not the only alternative to Alberta or to Canada."

Alberta, for instance, can send its natural gas by pipeline to eastern Canada, where it can displace oil imports. Even selling liquefied petroleum gas and other upgraded hydrocarbons to Japan, he says, may be preferable to straight-out gas sales to the U.S. The same holds true if Canada becomes a net exporter of oil.

The bottom line, Naegele believes, is that the U.S. will not preferentially get increased energy supplies from Canada for money alone. He suggests that the U.S. will have to open up its markets to selected, upgraded Canadian products. This will create much-needed jobs in Canada and improve its balance of payments.

Expanding upon Lougheed's proposal, Naegele thinks that the U.S. should allow duty-free access for a sizable list of Canadian petrochemicals—equal to 10% of the thermal content of the natural gas exported from Canada to the U.S. Mort testified that the effect of such a proposal on the U.S. petrochemical market would be negligible. Canada's petrochemical industry, though growing rapidly, isn't yet able to supply the full 10% of natural gas hydrocarbons as petrochemicals. Even when it can, Mort says, Canadian petrochemical exports would represent no more than 10% of the U.S. market. That's barely more than one year's growth in the U.S. market, which, he says, "would be a very small sacrifice in terms of U.S. industry growth in order to obtain such secure hydrocarbon supplies."

From a U.S. point of view, these proposals may sound like strong medicine. From the Canadian side of the border, they are perfectly reasonable.

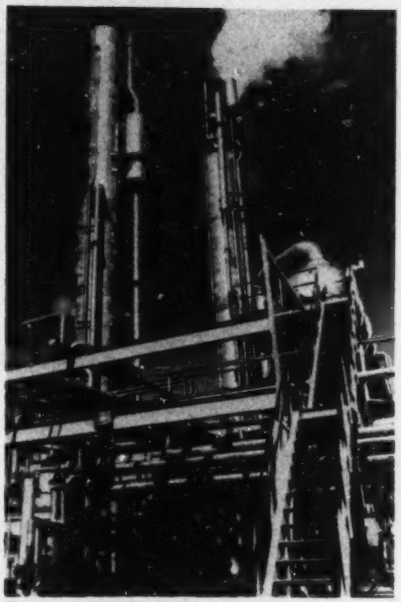
The Canadian petrochemical industry traditionally has been the weak sister of its U.S. counterpart. With small, inefficient plants, it has had trouble competing with imports, particularly from the U.S., in its own domestic market. Exports have been limited.

A small Canadian market, the quantum leap in the size of petrochemical plants required to remain competitive, and Canada's dependence on imported consumer goods combined to make life difficult for Canada's petrochemical producers.

Mort notes that, in the mid-seventies, Canada's per capita consumption of domestically produced ethylene derivatives was only half that of the U.S. There's not enough difference in the two countries' life styles to explain the disparity. Mort attributes it to the large part of Canada's petrochemical market supplied in the form of imported consumer goods such as household appliances, autos, and "plastic-handled screwdrivers." During those years, Mort says, one world-scale plant could have supplied the entire market available to Canadian producers of several key petrochemicals.

Now, fortified by an enviable hydrocarbons potential, Canada's petrochemical industry is starting to flex its muscles. But success will depend upon building economical, world-scale plants. They, in turn, will depend upon securing additional petrochemical markets outside Canada's borders.

In Canada, world-scale petrochemical plants already have arrived. Two major complexes have been put on stream in the past two years. One is the Petrosar project, a billion pound-per-year ethylene plant in Sarnia. Petrosar is a consortium of Union Carbide, Du Pont, Polysar, and Canadian Development Corp. The other is a major new petrochemical facility started up last year by Alberta Gas Ethylene. It is tied into a major fuel project and a pipeline operation.



Pemex's 1000 ton-per-day ammonia plant at Cosoleacaque, Mexico

With the Petrosar unit in place, Du Pont expanded high-density polyethylene capacity. Polysar built a huge new styrene monomer unit. Shell Chemical built polypropylene and isopropyl alcohol plants. Dow added a world-scale low-density polyethylene unit.

At the heart of the Alberta development are five plants that extract 85,000 bbl per day of ethane from Alberta's gas transmission lines. About 40% of this ethane feeds a 1.2 billion lb-per-year ethylene plant at Red Deer, Alta., owned by Alberta Gas Ethylene; the other 60% goes to U.S. markets through the Cochin pipeline.

Dow buys the full output of the Red Deer ethylene plant and consumes at least 700 million lb of it at its Fort Saskatchewan complex, where it produces ethylene dichloride, vinyl chloride, and ethylene glycol.

The Petrosar and Alberta plants have boosted Canadian ethylene capacity from 1.4 billion lb in 1977 to 3.4 billion lb per year. With the new satellite plants that have been built around these core complexes, capacity for ethylene derivatives has mushroomed. Polyethylene capacity has doubled. Ethylene glycol capacity has increased two and a half times. Vinyl chloride capacity has risen almost five fold. Styrene and polyvinyl chloride capacities have doubled.

Mort anticipates even more petrochemical expansions in Canada, based primarily on Alberta's natural gas. He says that enough ethane can be extracted from Alberta gas streams to produce an additional three to four billion lb of ethylene annually.

He expects ethylene production in Alberta to triple to 3.6 billion lb per year by 1986 or 1987. Much of it will be upgraded to ethylene derivatives. Mort also expects methanol production to quadruple from 140 million gal per year to about 600 million gal.

James M. Hay, who has succeeded Naegele as president of Dow of Canada, stresses, however, that how far and how fast Canada goes in petrochemicals depends largely on additional trade agreements. Canadian producers of aliphatics, in particular, are likely to continue hammering home this theme in Ottawa.

Aside from the obvious aliphatics producers, no broad-based support for freer trade with the U.S. or anyone else has surfaced in the Canadian chemical industry. Like many Canadian manufacturing industries, segments of the chemical industry have been built behind a protective tariff. They are more concerned with import competition than with export opportunities.

But broad-based industry support may yet appear. The Canadian Chemical Producers Association has hired a consultant to conduct a study of the industry's attitude toward freer trade. The results should be available later this year.

CIL senior vice president David I. W. Braide, who also chairs the association's trade policy committee, says that the Canadian chemical industry as a whole "isn't going hell-bent for leather" over the idea yet, although several individual companies may be. CIL itself is re-evaluating its position on the issue.

Naegele thinks that the producer association's survey will show there is wide support in the Canadian chemical industry for his proposal. He also thinks that Mexico could benefit from a similar deal with the U.S.

Like Canada, Mexico has a king's ransom in hydrocarbon resources. And like Canada, Mexico has ambitious plans for petrochemicals.

But there are some important differences between the two countries. For instance, Canada is a developed nation with a relatively small population of 23 milllion. Mexico is a developing country with a much larger population of 67 million.

Although Mexico has taken some giant strides in developing its petrochemical industry, it has a long way to go. It still isn't able to satisfy its ever-increasing domestic demand or to reduce its substantial petrochemical imports. Only when it licks these two problems will exports become a significant factor for Mexico's petrochemical industry.

That export capability may not be very long in coming. This year, Mexico figures to have 82 basic petrochemical plants operating with a total capacity of 8.9 million metric tons per year. All of these plants are owned by Petroleos Mexicanos (Pemex), the state-owned oil company that has a monopoly on production of almost 50 "basic" petrochemicals.

But Pemex is figuring on a petrochemical growth rate of 23.9% per year over the next five years. It plans to be operating 157 petrochemical plants by 1985. Capacity to produce basic petrochemicals will increase from 8.9 million metric tons to a hefty 26 million metric tons annually.

Most of that increase is earmarked for the Mexican market. Including Pemex's own internal requirements, Mexico's petrochemical demand is expected to increase from this year's 7 million metric tons to 21 million metric tons in 1985.

José Luis Garcia Luna, manager of petrochemical development for Pemex, says that exports of basic petrochemicals actually will decline over the next two years. By 1982, he estimates that exports will have dropped to 510,000 metric tons, less than half of what they will be this year.

After 1982, however, exports will start picking up steam again. By 1985, Garcia thinks that they will reach 2.8 million metric tons.

The logical market for these Mexican petrochemicals is the U.S. Consequently, it would seem that Mexico would be as interested as Canada in striking a bilateral deal with the U.S.—assured energy supplies in return for a bigger slice of the lucrative U.S. petrochemicals market.

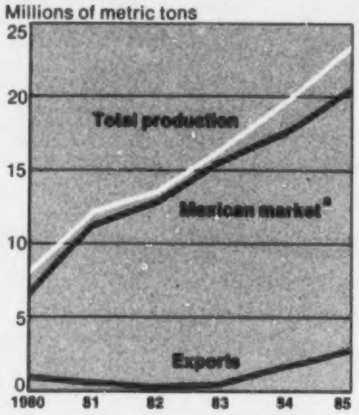
So far, there's no indication that Mexico is interested. Garcia says that he never has heard such a proposal discussed. Neither have several others involved in the Mexican chemical industry.

In fact, there's no evidence that, with the exception of a few academic economists, there's much thought being devoted in Mexico to any sort of North American trade alliance.

Mexican president José Lopes Portillo has stated flatly that Mexico isn't interested in a North American trade pact. And Mexico's recent decision not to join the General Agreement on Tariffs & Trade (GATT) indicates that for the time being, at least, Mexico intends to continue developing its industrial base behind a wall of high tariffs and other import barriers.

As to what U.S. petrochemical companies think about all of this, they have been noticeably silent about the issue, and an industrywide position may not become apparent until CMA's task group has something to say about the subject.

Mexico has hefty petrochemical ambitions



a Includes Pemex's internal consumption.
Source: Pemex (Petroleos Mexicanos)

One chemical industry trade expert says that he wants to know more about the Naegele proposal before he comments on it. Others are not that hesitant, at least off the record.

One company official says that the likes of a Naegele deal would make most of the U.S. petrochemical industry "pretty damned unhappy." Says another, "A considerable segment of the U.S. petrochemical industry will have great difficulty with it."

Behind these less-than-enthusiastic comments lies one disturbing thought. The prospect of obtaining secure energy supplies may benefit the entire U.S., but the petrochemical industry would pay the whole bill by sacrificing part of its own market.

There are other potential problems with a proposal such as Naegele suggests. Although he didn't say so directly, he at least intimated that Canadian producers want a specific share of the U.S. petrochemical market. And any talk about assigning a specific share of the U.S. market to foreign imports spells trouble.

There no doubt are ways that the stigma of market share can be skirted. "It's just that Bob was too crude about the way he phrased it," says one U.S. trade expert who knows Naegele.

Perhaps the biggest stumbling block to any bilateral or trilateral petrochemical deal is GATT. Under GATT rules, broad regional trade blocs are permitted: Narrow, sectoral arrangements are not.

It's true that GATT gave its blessing in the form of a waiver to the U.S.-Canadian automotive agreement. But when that deal was worked out, Japanese and European cars weren't the factor on the U.S. market that they now are. And the U.S. had much more clout with GATT in those days than it does now.

In the auto pact, fewer companies are involved than there would be in a petrochemicals deal. With petrochemicals, the product mix is more complex. European chemical companies no doubt would try to block a North American petrochemical pact because the U.S. figures heavily in their marketing plans.

Again, there are possible solutions. One would be to negotiate bilaterally or trilaterally, then apply the results of the negotiations on a multilateral basis. A GATT waiver then would not be necessary. But this could open up a whole new can of worms.

The U.S. would expect concessions from those countries that didn't participate in, but received the benefits of, any North American agreement. That puts the U.S. right into the thick of another multilateral trade negotiation.

Thus, it seems that insurmountable problems must be overcome before there can be a North American trade alliance. These problems exist in Mexico, in Canada, and in the U.S.

Mexicans and Canadians alike rebel at the idea of, as they put it, "giving away" their energy resources. Mexico still clings to a protectionist policy, which is politically popular at home.

In Canada, the idea of freer trade is winning more and more converts, but the issue is far from resolved. Meanwhile, serious problems such as the constitutional issue and energy policy pits province against province and province against the central government. These problems will keep freer trade off the front burner for a while.

Many Canadians and Mexicans feel uncomfortable thinking about an economic alliance with a country as large as the U.S. Canadian Prime Minister Pierre Elliott Trudeau said it all when he said that being a neighbor of the U.S. is like being in bed with an elephant. Even a friendly elephant can roll over in the middle of the night.

Sectoral arrangements, such as those being considered for petrochemicals, present fewer and less formidable problems. But they are not inconsequential.

Meanwhile, the U.S. chemical industry isn't taking anything for granted. Max Turnipseed believes that petrochemicals will be an important part of any North American trade negotiations. And, he adds, "We want to have as much input as possible into the thought process." □

Chemical & Engineering NEWS

FINAL PROGRAM
Second Chemical Congress
of the North American Continent
San Francisco Page 44

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Versatile computer graphics for showing structures Page 27

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Chemical & Engineering NEWS

Cover: Computer graphics system, developed at the University of California, San Francisco, can display important molecular features, such as how the hormone thyroxine (magenta, with its molecular surface depicted by dots) fits into protein prealbumin's specific binding site, depicted by green dots

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- ***Second-quarter earnings*** *of U.S. chemical companies reflect poor markets and rising raw materials costs.* ***Page 10***
- ***Decline in U.S. chemical production*** *is accelerating, roughly paralleling the drop in overall industrial output.* ***Page 11***
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- ***GAO investigation*** *of effectiveness of FDA's Bureau of Biologics, prompted by five Senators, finds few failings.* ***Page 12***

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- ***Department of Energy*** *funds studies and projects to stimulate U.S. production of synthetic fuels.* ***Page 22***

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- ***Computer graphics display system*** *shows three-dimensional color images of molecule surfaces that can be manipulated to depict molecular interactions.* ***Page 27***

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- ***In-situ gasification of low-grade coal*** *reserves in the West is feasible, data from Wyoming study indicate.* ***Page 37***
- ***Interox America*** *hopes to crack U.S. detergent market with new process for making sodium percarbonate.* ***Page 39***

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- ***Official reports*** *of society, board, and other committees at the June ACS Board of Directors meeting.* ***Page 41***
- ***ACS books, journals,*** *other educational services viewed by delegates of China National Publications Import Corp.* ***Page 42***

Final Program

- ***Complete technical program,*** *listing of social events for the Second Chemical Congress of North American Continent to be held in San Francisco next month.* ***Page 44*** a 10% sales increase at Rohm & Haas, earnings fell 20% on a 3% sales rise at Stauffer Chemical, and earnings fell 16% on a 4% sales increase at Union Carbide.

Although official earnings statements have yet to be released, Du Pont and Celanese are predicting falling earnings for the second quarter. At a security analysts meeting in Frankfurt, West Germany, Du Pont's senior vice president Richard E. Heckert said that the company's second-quarter earnings will be "down significantly from the $1.59 per share earned in the second quarter of last year." Du Pont's sales, he says, will be up slightly from the $3.24 billion level of the 1979 second quarter, but the gain will be due almost entirely to higher selling prices.

Celanese's earnings for the second quarter are expected to fall about 45% from last year's second-quarter income of $45 million. In a registration statement with the Securities & Exchange Commission, Celanese said that the economic downturn in the U.S. caused a sharp falloff in demand for chemicals starting in mid-April and that weak demand continues for fibers, plastics, and specialty products for autos, housing, and textiles.

The downturn in housing is having a big impact on other companies, too. PPG Industries' earnings for the second quarter fell 31.2% to $39.7 million from the second quarter last year. The big surprise at PPG is that sales also are off—almost 4% to about $754 million.

And at Owens-Corning Fiberglas, which is even more closely tied to the housing and other durable goods markets, the situation is worse. Sales at Owens-Corning for the second quarter fell 5.6% from a year ago to about $496 million. For the quarter the company lost $2.1 million, compared with earnings of $17.2 million in second-quarter 1979.

There have been a couple of bright spots thus far in earnings reports. At Diamond Shamrock, second-quarter earnings jumped 34% from a year ago, and sales moved up 6%. At W. R. Grace, second-quarter earnings climbed 36% as sales went up 13%.

At Texasgulf, second-quarter earnings rose 83% to about $599 million on a sales increase of 18.3% to nearly $241 million. □

U.S. chemical output decline accelerating

By the middle of May, U.S. chemical producers knew that the props had been knocked out from their business volume as the spreading U.S. recession reached their operations (C&EN, May 12, page 6). Now official figures show how bad the damage was that month and how sharply the recession is shaping up.

U.S. chemical production is in an accelerating decline, with the worst of it to date toward downstream or derivative products closer to the final consumer. Seasonally adjusted indexes from the Federal Reserve Board show production of chemicals and allied products in May at 204.7 (1967 = 100). This represents a 3% drop in just one month from a downward revised 210.2 in April. The April index figure is 2% below 214.5 in March.

The May production level is now 6% less than the record 217.7 in January during the industry's strong first quarter. May output is also below the level of a year ago by 2%; it's the first month to show a year-to-year decline.

At this rate, the chemical industry is roughly paralleling the overall drop in U.S. industrial production, starting at about the same time and proceeding at about the same rate. FRB's index for total industrial production in May was down 5% from the recent high point in January.

The total production index hints that June brought another thumping drop in chemical output. The overall index sank 2% in June to a seasonally adjusted 141.2 or at about the same rate as in May. Since the chemical indexes run a month behind the total indexes, it will be August before the extent of a chemical decline in June becomes evident.

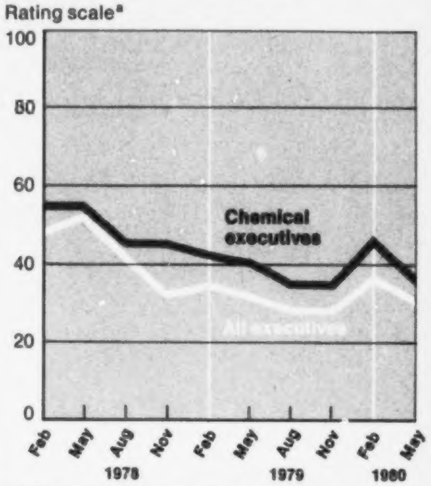
However, Labor Department data on the workweek at chemical plants in June already hint that another production drop took place (C&EN, July 14, page 9). The workweek for chemicals and allied products fell in June to a seasonally adjusted 41.1 hours from 41.5 hours in May. As these data go, this is a substantial drop for one month.

Within the broad chemical industry, subindexes show that the production decline has reached upstream to the most basic products, but the steepest part of it is still in downstream polymers. For synthetic materials (plastics, fibers, and elastomers), FRB's seasonally adjusted index slumped 7% in May from April to 282.9. This level also is 12% below May 1979. The new reading for synthetic materials is now down 17% from the record high of 339.3 in January.

For basic chemicals, the production index slipped 1% in May from April to 189.6. This index also is down 1% from May 1979 and has fallen 4% from its record high of 196.9 in December 1979.

Chemical executives have lowered their sights in this production environment. In a quarterly survey in May of executive confidence by the Conference Board, a business research group in New York City, chemical chief executives rated the

Chemical execs' expectations fell sharply this spring



[a] U.S. executives' expectations on a scale of 0 (worst) to 100 (best) for own industry (chemical executives) or general economy (all executives) six months ahead.
Source: Conference Board

May production fell hardest in polymers

Indexes, 1967 = 100	1980 May	1980 April	1980 March	1980 February	1980 January	1979 May	% change April–May	% change May–May
Chemicals and allied products	204.7	210.2	214.5	216.0	217.7	209.7	−3%	−2%
Chemicals and synthetic materials	220.3	228.5	234.0	238.1	243.2	233.8	−4	−6
Basic chemicals	189.6	191.9	196.0	193.7	196.0	190.8	−1	−1
Synthetic materials (polymers)	282.9	303.1	311.4	328.4	339.3	321.3	−7	−12
Total U.S. production[a]	144.7	148.3	151.7	152.3	152.6	152.4	−2	−5

[a] June index is 141.2, down 2% from May; June indexes for chemicals are lagged one month. **Source:** Federal Reserve Board

business outlook over the next six months at a low 37 on a scale of 0 to 100. This is down from 47 in February and 41 a year ago.

Chemical chief executives felt even worse about the current business scene in May. They rated their business condition compared to six months ago at 30 on a similar scale of 0 to 100, down from 46 in February and 57 in May 1979.

How far the production falloff will go and when it will stop are still open questions. June certainly brought no letup, and worsening price discounts in basic chemicals in July hint that this won't be the turnaround month either. Privately, some industry forecasters say the low point may not arrive until October, and recovery not until 1981. ☐

Dire environmental outlook for year 2000
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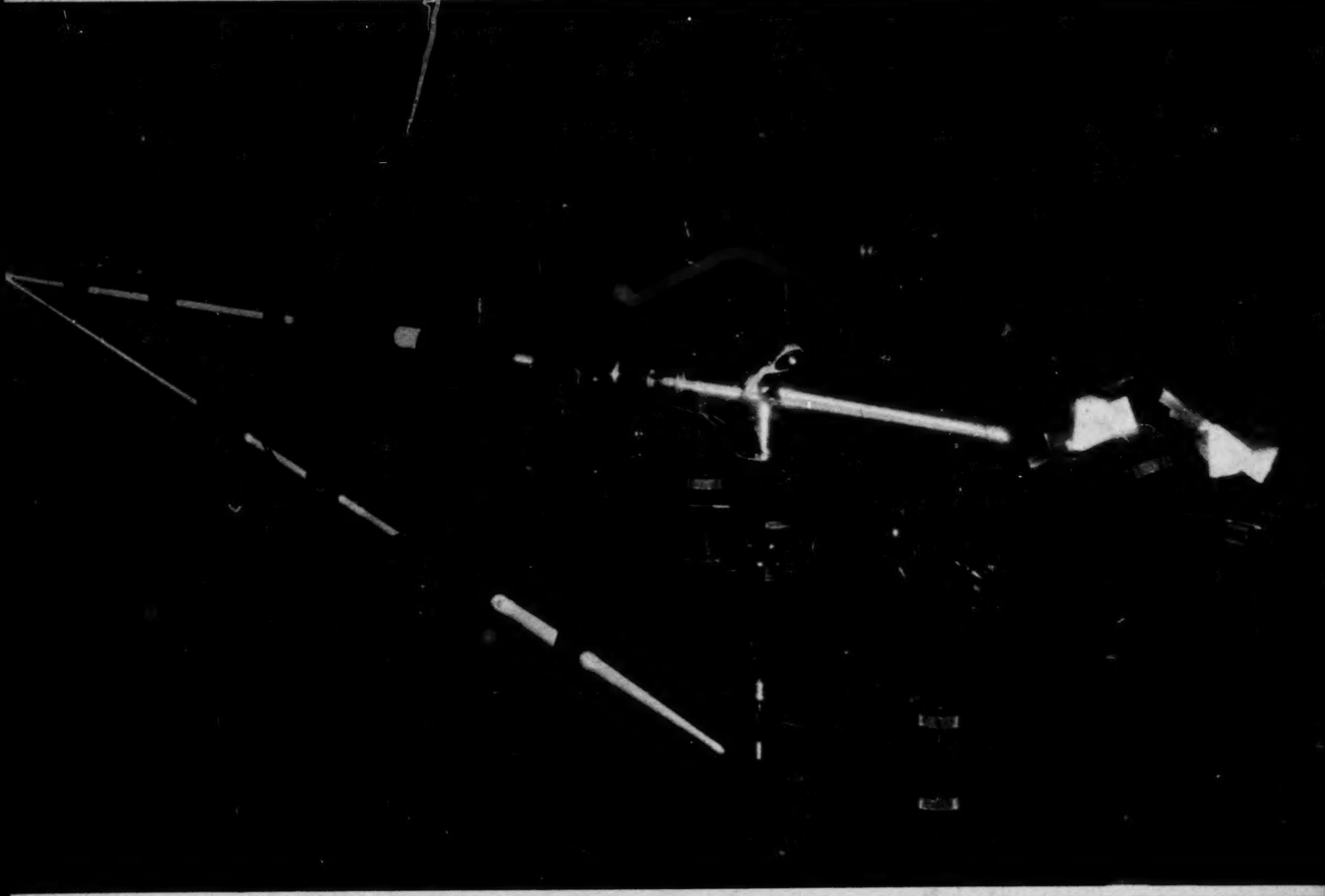

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News of the Week

- ***Second-quarter earnings*** *of U.S. chemical companies are down an average of 18% from the same period last year.* ***Page 10***
- ***U.S. yachts contending for the America's Cup*** *will carry sails made with Mylar polyester film.* ***Page 11***
- ***As much as 20% of U.S. energy needs*** *could be met by biomass by the end of the century, OTA predicts.* ***Page 11***
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- ***Clinical testing of insulin*** *produced by bacteria is being carried out by British subsidiary of Eli Lilly & Co.* ***Page 12***
- ***Two programs to study ethical dimensions*** *of science, engineering, and medicine will be sponsored by NSF and the National Endowment for the Humanities.* ***Page 12***

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- ***World survey of company annual reports*** *finds wide variation in quality of data and concludes international accounting standards are needed.* ***Page 18***

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- ***Large-diameter polyethylene piping*** *for sewer system, connected by gasketed joints, cuts costs substantially.* ***Page 28***
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Special Report

Facts & Figures for Chemical R&D *gives broad view of overall U.S. R&D effort plus detailed picture of funding by the federal government and by industry, how universities fare.* ***Page 37***

CHEMICAL EARNINGS DROP IN SECOND QUARTER

U.S. chemical companies weren't kidding when they warned late in the second quarter that earnings had been hit hard (C&EN, June 30, page 4). With a few exceptions, leading chemical producers have reported mild to severe drops in earnings from second-quarter 1979. Some have even reported sales declines from last year.

Overall, results to date from 25 of the 40 chemical companies in C&EN's quarterly earnings survey show that earnings are down an average of 18% in the second quarter from a year ago on a 6% gain in sales. That's quite a reverse from the first quarter, when the year-to-year comparisons showed average earnings still up 31% and sales up 21%.

The earnings decline in the second quarter leaves the chemical industry barely above a flat performance for first-half 1980. Through the first six months, average earnings for the 25 companies reporting so far are now just 2% ahead of 1979, and sales are up 12%.

Needless to say, profit margins have fallen. For the second quarter combined after-tax profit margin on sales for the 25 companies was 5.4% compared to 7.0% in second-quarter 1979. For first-half 1980, combined profit margin for these companies has slipped to 6.4% from 7.0% in 1979.

The earnings range among companies has moved way down from the heights of the first quarter. In the second quarter, the leading gainer to date is Texasgulf with earnings up 83% from a year ago. The worst drop was at Reichhold Chemicals, whose earnings are down 97%. Of the 25 companies, 19 suffered lower earnings than in second-quarter 1979.

Companies with earnings down more than half from a year ago in the second quarter also included B. F. Goodrich, off 59%; Monsanto, off 61%; and Akzona, off 71%. Other notable drops at the largest companies were 16% at Union Carbide, 20% at Dow Chemical, 25% at American Cyanamid, 34% at Du Pont, and 44% at Celanese.

Sales fell at four of the companies in the second quarter—1% at Celanese and National Distillers, 4% at PPG Industries, and 6% at Reichhold Chemicals. No company's sales were lower for the first half of the year.

At the other extreme, there were only four companies with double-digit earnings increases in the second quarter. Besides Texasgulf's 83% jump on an 18% sales increase, W. R. Grace's earnings rose 47% on a 13% sales gain, Big Three Industries'

Only a few companies manage earnings gain in second quarter

	Second-quarter 1980						First-half 1980					
$ Millions	Sales	Change from 1979	Earnings[a]	Change from 1979	Profit margin[b] 1980	Profit margin[b] 1979	Sales	Change from 1979	Earnings[a]	Change from 1979	Profit margin[b] 1980	Profit margin[b] 1979
Akzona	$ 244.4	3%	$ 1.4	−71%	0.6%	2.1%	$ 537.6	8%	$ 6.8	−53%	1.3%	2.9%
Air Products	356.9	16	26.9	8	7.6	8.1	734.1	21	61.2	24	8.3	8.1
American Cyanamid	837.0	5	32.6	−25	3.9	5.4	1667.0	8	70.6	−16	4.2	5.4
Big Three Industries	154.3	26	20.4	36	13.2	12.3	307.1	26	40.7	37	13.3	12.3
Celanese	803.0	−1	25.0	−44	3.1	5.6	1650.0	6	61.0	−21	3.7	5.0
Diamond Shamrock	769.1	34	56.3	6	7.3	9.2	1524.5	41	112.6	36	7.4	7.6
Dow Chemical	2522.7	9	171.2	−20	6.8	9.3	5332.2	22	401.7	3	7.5	8.9
Du Pont[c]	3412.3	5	176.6	−34	5.1	8.3	6980.2	11	421.0	−18	6.0	8.2
Ethyl[c]	440.5	7	24.1	−8	5.5	6.4	879.1	12	45.3	−4	5.2	6.1
Ferro	170.9	17	4.7	−35	2.8	5.0	340.4	21	11.8	−27	3.5	5.0
Freeport Minerals[c]	147.6	20	29.8	18	20.2	20.7	304.0	33	65.1	43	21.4	20.0
B. F. Goodrich	749.9	0	10.0	−59	1.3	3.3	1520.0	1	30.0	−40	2.0	3.4
W. R. Grace	1541.4	13	86.7	47	5.6	4.4	2905.5	15	151.9	53	5.2	3.9
Hercules	624.0	6	26.9	−33	4.3	6.8	1269.0	11	60.6	−21	4.8	6.7
Monsanto	1548.6	1	23.2	−61	1.5	3.9	3371.1	7	187.4	−15	5.6	7.0
National Distillers[c]	512.7	−1	29.6	−3	5.8	5.9	1071.2	1	72.7	16	6.8	5.9
Olin	483.4	2	27.2	−1	5.6	5.8	958.7	5	49.2	10	5.1	4.9
Pennwalt[c]	292.4	8	10.9	−22	3.7	5.2	595.2	12	23.2	−3	3.9	4.5
PPG Industries	753.7	−4	39.7	−31	5.3	7.4	1550.0	3	94.4	−12	6.1	7.1
Reichhold Chemicals	213.2	−6	0.2	−97	0.1	2.6	449.5	4	4.4	−48	1.0	2.0
Rohm & Haas	467.1	10	27.0	−1	5.8	6.4	902.8	11	54.2	−2	6.0	6.8
Stauffer Chemical	357.1	3	20.0	−20	5.6	7.2	940.0	11	89.7	3	9.5	10.3
Texasgulf[c]	240.6	18	59.1	83	24.6	15.9	520.6	38	136.7	137	26.3	15.3
Thiokol	153.2	5	7.7	−7	5.0	5.7	308.1	10	17.3	11	5.6	5.5
Union Carbide[c]	2370.9	4	149.9	−16	6.3	7.8	4936.5	11	369.8	11	7.5	7.5

a After-tax, before major extraordinary or nonrecurring items, for continuing operations. b After-tax income as a percentage of sales. c Earnings exclude major extraordinary or nonrecurring items.

earnings rose 36% on a 26% sales increase, and Freeport Minerals' earnings gained 18% on a 20% sales rise. Big Three continued its aggressive growth in industrial gases and oil field services, and the other three profited from agricultural chemicals, especially in export markets, and from natural resources.

Chemical company leaders are emerging a bit startled from the second quarter. "We and other chemical producers were somewhat surprised by the severity of reduced demand in the second quarter, which also led to poor operating rates," says John D. Ong, chairman of B. F. Goodrich.

John W. Hanley, Monsanto chairman, comments, "While we had anticipated an economic downturn, we had not projected adequately the extent of the credit constraints imposed by the Federal Reserve and the significant impact that those credit constraints had on the demand for automobiles and housing."

At Dow Chemical, financial vice president G. J. Williams elaborates, "New orders dropped abruptly in the U.S. in late April, and this resulted in reduced shipments for the quarter. In most other areas of the world, business was mixed, with Latin America and some countries in Europe showing continued strength."

Business outside the U.S. helped shore up other multinationals as well. For example, Du Pont's sales abroad were up 16% in the second quarter from a year ago but flat in the U.S. with a physical volume decline in the U.S. of 14%. Similarly, Union Carbide's international sales gained 13% in the second quarter but U.S. sales were dead-even on a physical volume drop of 17%.

Some companies survived the second quarter with only moderate earnings damage because of hot-performing specialty businesses. Examples are Olin with its swimming pool chemicals market and Rohm & Haas with herbicides. Grace also comments on favorable performance from its array of chemical specialties.

From this point, some companies are prepared for worse than they expected. Dow's Williams says, "It now appears that the recession will be deeper and longer than we had previously thought. We therefore don't expect that our net income for the year will equal that of 1979."

The same sort of talk comes from James G. Affleck, chairman of American Cyanamid. "We now expect that earnings for the year as a whole will fall below the record level of 1979. Our expectations are based on the likelihood that the U.S. recession will be deeper and longer than originally anticipated." □

Plastics demand drops sharply

Sales of this major product group plummeted this spring, trailing far behind production and pointing toward inventory pileup

Plastics have carried much of the load in the U.S. chemical industry's growth in the past few years. It's the only major product group in the industry that kept up its torrid growth in the 1970's from the 1960's, and it's the best bet for future growth.

But 1980 has dealt plastics a rough start in the new decade. Contrary to expectations six months ago that plastics would survive the recession with only modest damage, results this spring show a severe drop in demand, worse than the general volume drop in the broad chemical industry.

Whereas in May, the latest month for which data are available, production fell 2% from a year ago for chemicals and allied products and 12% for overall polymers (C&EN, July 21, page 11), output dropped 20% in the leading plastics, according to data from the Society of the Plastics Industry's Committee on Resin Statistics as compiled by Ernst & Whinney. As a downstream product group more immediately vulnerable to final consumer demand than basic chemicals, plastics easily might fall earlier and faster than upstream chemicals. But the May data show a very large gap indeed and foretell a lot of trouble for basic chemicals in the next few months.

The jolt in plastics demand this spring has pulled both production and sales below levels of first-half 1979. Continuation through some or all of the second half of the year could produce an infrequent event, annual decline in plastics volume. This has happened only once before in recent decades, in the equally precipitous recession of 1975.

The air pocket in plastics use probably has caught producers in a big inventory backup. SPI's data show plastics sales far behind production this spring after a general lag over much of the past year. For example, year-to-year production dropped 20% and sales declined 29% in May after 6% and 15% drops in April for leading plastics. Before then, annual gains in sales trailed gains in production every month back to July 1979.

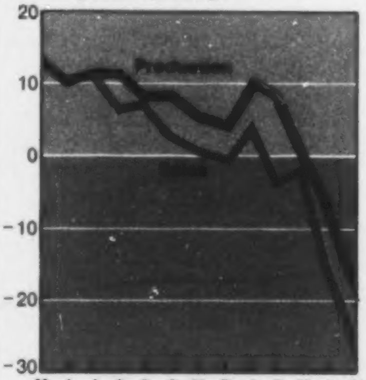
The inventory load will tend to hold down production over the next few months. This means low rates of plant use and a steep decline in profits.

Second-quarter reports from leading chemical companies tell the result even before the arrival of June production figures. At Monsanto, which is a big producer of styrenic plastics, operating income data (pretax, precorporate overhead) for plastics in the second quarter show a loss of $13.3 million after a profit of $9.7 million a year ago.

Other companies are more qualitative in their plastics reporting but leave no doubt that the second quarter was difficult. At Dow Chemical, the largest U.S. plastics producer, financial vice president G. J. Williams says that worldwide plastics weakened in the period. However, he adds they are still in healthy shape.

At companies less committed to the relatively strong polyethylenes, words were more somber. This is especially true for polyvinyl chloride producers, who have the worst problems among companies in the dominant thermoplastics. PVC production slumped 28% and sales 36% in May from a year ago.

Plastics sales decline has led that of production



Note: Totals for epoxy, polyester, urea, melamine, phenolic, low-density polyethylene, high-density polyethylene, polypropylene, polystyrene, and polyvinyl chloride. **Source:** Society of the Plastics Industry's Committee on Resin Statistics as compiled by Ernst & Whinney

The weakness in PVC resins, used in the automotive and construction industries, was especially marked among Stauffer Chemical's U.S. product lines, according to chairman H. Barclay Morley. At Diamond Shamrock, another major PVC producer, chairman W. H. Bricker says, "Plastics showed a sharp drop in performance late in the quarter, moving from its excellent first quarter levels, primarily as a result of the depressed construction and automotive industries, its principal markets." However, Bricker adds, "Since customer inventories appear to have remained low, when it comes, a turnaround in demand should increase earnings rapidly in plastics."

The specific source of PVC's trouble isn't hard to locate. Its leading market, construction pipe, is doing even worse than overall demand. "Demand for pipe was poor," says John McKinney, chairman of one leading PVC pipe producer, Johns-Manville. In May, SPI figures show pipe sales down 49% from May 1979. For the first five months of 1980, pipe sales fell 17% from the same period in 1979.

Unfortunately, this situation is true for several other leading plastics: The big markets are doing worse than the average and the more specialized markets aren't big enough to counter the drop. For the most widely used plastic, low-density polyethylene, cumulative 1980 sales have dropped 3% through May from a year ago, but sales in film, by far the largest single LDPE market, have dropped 8%. In May alone, total LDPE sales were down 29% and film sales down 34% from May 1979.

For polypropylene, the two largest uses, molding and fibers, both turned in substantially worse results than the product's overall 21% sales drop in May. The same is true for polystyrene's largest use in packaging, epoxy's in coatings, and polyester's in reinforced plastics.

May drop hit all major plastics; exports held up

	Year-to-year change, May	
	Sales	Exports
Epoxy	−26%	−11%
Polyester	−43	−1
Urea-melamine	−24	42
Phenolics	−27	−24
Low-density polyethylene	−29	12
High-density polyethylene	−24	−8
Polypropylene	−21	1
Polystyrene	−31	10
Polyvinyl chloride	−36	51
TOTAL	−29	7

Source: Society of the Plastics Industry's Committee on Resin Statistics as compiled by Ernst & Whinney

Plastics producers had been counting on exports to balance any softening in U.S. markets in 1980. Although export totals for the first five months of the year for leading plastics do show a good gain of 17% from the same period in 1979, the year-to-year rate of gain is declining.

The export picture is actually quite mixed for different plastics. It's still very strong in volume gains for PVC, with year-to-year jumps of 78% for the first five months of 1980 and 51% in May. Exports are still increasing healthily for LDPE, the export leader, with corresponding increases of 30% and 12%, and for polystyrene, with increases of 34% and 10%.

However, among these thermoplastics, which make up the great majority of plastics exports, high-density polyethylene exports are down 3% for the first five months of 1980 and 8% in May from year-ago figures. And polypropylene exports are down 7% for the first five months, although up 1% in May.

In the thermosets, exports are small compared to the thermoplastics and are in worse shape. The only major thermoset with cumulative rising exports through May this year is epoxy, which has a 28% gain year-to-year. However, May exports of epoxies were down 11% from May 1979. For three other leading thermosets, exports are well down for the first five months of 1980 from the same period in 1979—off 19% in polyester, 27% in urea-melamine, and 15% in phenolics.

Unhappily, export volume cannot make up for the destructive drops in the U.S. plastics market. As business slowdowns loom larger in Europe and elsewhere, even this much export relief may fade. Plastics are in for a rocky time in the U.S. until demand turns around in major markets.

William Fallwell, New York

Facts & Figures for Chemical R&D

Research and development is a key factor in the overall U.S. economy. It is an endeavor that, in itself, probably will absorb more than $60 billion this year for the first time ever. Since the mid-1970's, R&D outlays have been advancing steadily at an annual rate of 11%. Furthermore, they support the efforts of some 660,000 scientists and engineers (in addition to an uncounted number of technicians and other support personnel), a number that has been expanding about 5% a year recently.

But the real economic significance of R&D is far greater than its 2.3% share of the nation's gross national product might suggest. For R&D underpins the nation's technological progress and its health, defense, commerce, and general well-being.

Nor can its significance be measured adequately merely in terms of money and manpower. Its payoff is in new ideas, products, and processes whose contribution can be quantified only nebulously.

Nonetheless, money and manpower data are the best measures available. On the following pages, C&EN, in its second annual report on R&D, has compiled a variety of key data: on who supplies the funds needed to make the process go, on where and how they are spent, and on the scientists and engineers who do the work. The focus throughout is on R&D in chemistry and the chemical industry. As a whole, the figures serve not just to map the present dimensions of the nation's R&D enterprise but as indicators of the trends that are likely to shape its further development in the decade ahead.

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Chemical R&D

R&D spending rose 9% a year in past decade, but inflation wiped out most of gain

The nation continues to invest more and more money in chemical research and development. Definite figures on the total amount spent on chemical R&D are not available, however. C&EN estimates that government agencies, industry, and academic and other nonprofit organizations devote more than $5 billion to such R&D.

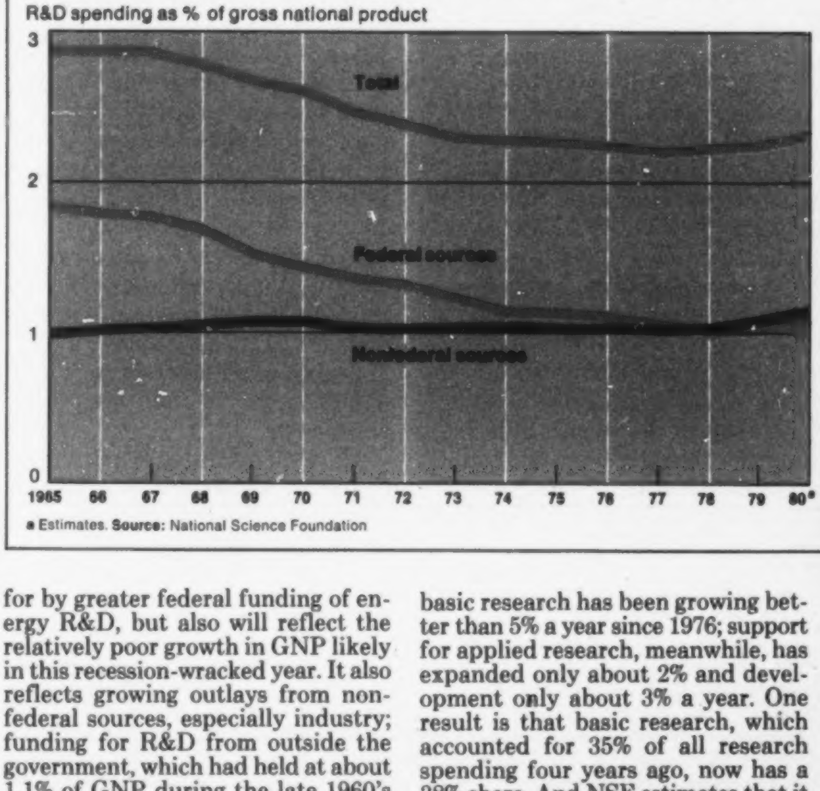
At the same time, the number of employed chemists in the U.S. is growing. According to the latest National Science Foundation (NSF) data, the number rose 8% from 133,500 in 1974 to 143,700 in 1978.

U.S. spending for all R&D is also on the increase. According to NSF estimates, it will climb 11% from $54.3 billion in 1979 to $60.4 billion in 1980. Between 1970 and 1980, total R&D spending has risen 133%—or nearly 9% a year.

But inflation has made these increases much less impressive in terms of constant dollars. Because of the rising costs of personnel, equipment, supplies, and overhead, the growth of total R&D spending in constant 1972 dollars will be only 2% this year and the increase between 1970 and 1980 will be just 17%—less than 2% annually.

Of deep concern to many people, the share of gross national product devoted to R&D for several years now has been well below what it was in the mid-1960's. R&D spending peaked in 1964 at just under 3% of GNP, dropped persistently between 1967 and 1974 to about 2.3% of GNP, and has hovered close to that level since. The drop during the late 1960's and early 1970's stemmed largely from decreased federal funding of R&D for defense and space projects. Since 1977, however, there has been a slight upward trend in the percentage, and this year total R&D outlays are expected to edge above 2.3% of GNP after having been just under that level during the four previous years. The 1980 increase will be partly accounted for by greater federal funding of energy R&D, but also will reflect the relatively poor growth in GNP likely in this recession-wracked year. It also reflects growing outlays from nonfederal sources, especially industry; funding for R&D from outside the government, which had held at about 1.1% of GNP during the late 1960's until about 1977, may hit a new high of 1.2% of GNP this year.

Little change in R&D's share of U.S. GNP since early 1970's



a Estimates. **Source:** National Science Foundation

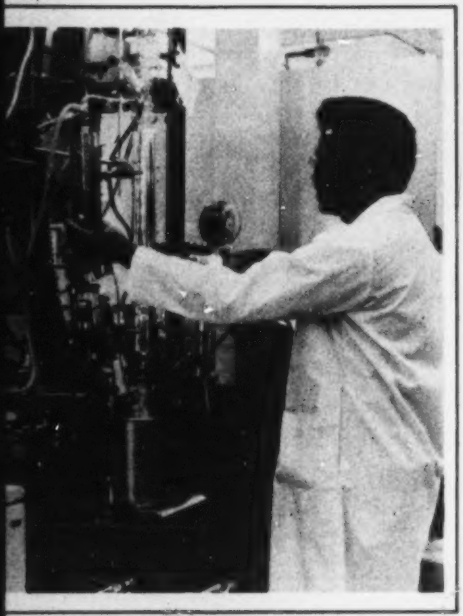
As far as basic science is concerned, such research as a per cent of GNP has declined from slightly less than 0.4% in 1965 to about 0.3% in 1979. The figure has remained at 0.3% or slightly less since 1973.

Actually, basic research appears to be strengthening, however, at least relative to other forms of R&D. NSF estimates that basic outlays will increase nearly 13% this year, compared to gains of 11% for both applied research and development work. After adjustment for inflation, funding for basic research has been growing better than 5% a year since 1976; support for applied research, meanwhile, has expanded only about 2% and development only about 3% a year. One result is that basic research, which accounted for 35% of all research spending four years ago, now has a 38% share. And NSF estimates that it will get nearly 40% next year, thanks largely to increased support from the government, which funds 70% of basic work.

For many years, the leading source of the nation's R&D funds was the federal government. In 1970, the government supplied 57% of these funds, compared to 40% from industry. Universities, colleges, and other nonprofit institutions provided the remaining 3%. In recent years, the government's lead has been dwindling. In 1980, the government furnished an estimated 49% of R&D funds, and industry accounted for

48%. NSF predicts that, next year, the government's contribution actually will be slightly less than that of industry.

Over the years, noticeable changes have taken place in the emphasis put on various types of R&D. In 1960, 52% of all R&D funds went for federally supported, defense-related R&D, 3% for space-related work, and 9% for civilian-related work. By 1965, only 33% of all R&D funds went for federally supported defense R&D, 21% for space programs, and 11% for civilian programs—as a result of decreased emphasis on defense and the greatly increased stress on space efforts. In 1980, the figures are once again considerably different. Some 24% of all R&D funds are expected to be devoted to defense projects, 8% to space, and 17% to civilian-related R&D (a large share of it concerned with health, energy, and environmental matters).



Federal spending for chemical research has about doubled from $236 million in 1970 to an estimated $479 million in 1980. Taking inflation into account, however, the increase was slight. In constant 1972 dollars, the spending during this period rose only 2% from $260 million to an estimated $265 million.

Among federal agencies, the leading supporters of total R&D are (in decreasing order) the Department of Defense, the Department of Energy, and the National Aeronautics & Space Administration. In the area of basic chemical research, the main sources of federal funds are the National Science Foundation, the Department of Energy, the National Institutes of Health, and the Department of Defense.

In 1980, the government has made a special effort to boost support of basic research. But because of inflation, the real growth of such spending was minor.

According to C&EN estimates, R&D carried out by the chemicals and allied products industry rose 14% in 1979 to $4.1 billion. Of the amount in 1979, 90% was supplied by the industry itself and only 10% by the government. This situation differs markedly from that in universities, where the chief provider of R&D funds is Uncle Sam.

In 1979, the industrial chemicals industry, according to C&EN estimates, performed R&D costing $2.1 billion. This, too, was a gain of 14% over 1978. Producers of industrial chemicals have more than doubled their R&D spending significantly during the past decade. In constant 1972 dollars, however, the gain during this period has been a mere 8%, from $1.2 billion in 1969 to $1.3 billion last year.

Even though spending on R&D in the industrial chemicals industry has been growing over the years, it has declined as a percentage of the industry's sales from 4.7% in 1965 to an estimated 3.3% in 1979.

In the drug industry, not only is R&D spending as a per cent of net sales stabler but also decidedly higher. The figures were 6.4% in 1965 and an estimated 6.3% in 1979. It had reached a peak of 6.7% in 1970.

U.S. companies are doing more and more R&D these days in their foreign affiliates. One reason is that such R&D makes it easier for U.S. companies to sell their products abroad by tailoring them to local needs. Between 1978 and 1979, the U.S. chemicals and allied products industry increased its R&D in its foreign affiliates 16% from an estimated $396 million to $460 million. The growth was even greater in the drug industry, which boosted R&D in its foreign affiliates 19% from an estimated $243 million in 1978 to $290 million in 1979.

The federal government pays for two thirds of the R&D done in universities and colleges. Most of the remaining financial support comes from the institutions themselves (13% of the total) or from state and local governments (9%). Industry's share is less than 5%.

Of the $5.3 billion spent by universities on R&D in 1979, 70% went for basic research, 25% for applied research, and 5% for development.

Actually, universities conducted a higher percentage of basic research in 1969. In that year, such research accounted for 77% of their total R&D spending of $2.2 billion. The remainder consisted of 18% for applied research and 5% for development.

Only 4% of university R&D is devoted to chemistry. This is not much different from the 5% for 1968.

Data from NSF and other sources provide information on characteristics of R&D manpower. NSF data show that, of the 146,600 chemists in the 1978 labor force, which includes both employed and unemployed, 91% were men and 9% women. Some 95% were white, 2% black, 2% Asian, and 1% other minorities.

In 1978, 65% of employed chemists worked in industry and 21% in educational institutions. Some 14% worked in basic research, 16% in applied research, 15% in development, 10% in teaching, and the remaining 45% in other activities, such as production, management, and consulting.

The number of chemists working for the federal government has fluctuated moderately in recent years. It rose from 8100 in 1970 to 8400 in 1972, dropped to 8000 in 1975, then climbed back to 8300 in 1978. The federal agencies that employ the most chemists are (in decreasing order) the Department of Health & Human Services, the Department of Defense, and the Department of Agriculture.

In the chemicals and allied products industry, the number of R&D scientists and engineers has risen 27% from 38,900 in 1968 to 49,400 in 1979. On the other hand, the number of such personnel in the industrial chemicals industry has declined slightly from 22,300 to 21,800.

The number of R&D scientists and engineers per 1000 employees in the chemicals and allied products industry has climbed 20% from 35 in 1968 to 42 in 1978. In the same period, the number of such personnel per 1000 employees in the industrial chemicals industry rose 22% from 32 to 39.

With the anticipated dropoff in enrollments in the 1980's in the universities, the number of scientists and engineers employed in these schools is expected to decline. In the 1970's, however, the number increased. For full- and part-time chemists, the number employed at Ph.D.-granting institutions rose 15% from 7900 in 1973 to 9100 in 1979. For full-time chemists employed at these institutions, the number climbed 13% from 6900 in 1973 to 7800 in 1979.

Despite concern about the nation's current economic downturn, the U.S. investment in chemical R&D is certain to increase in the years immediately ahead—both in total dollars spent and manpower employed. □

R&D

SECTION 1 Overview

R&D outlays likely to rise 11% this year and next

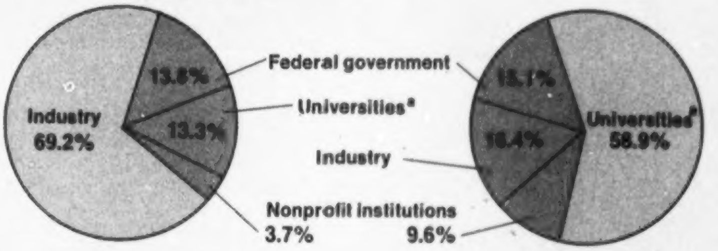
Spending is even expanding after adjustment for inflation thanks largely to industrial funds, but not so much as during the late 1970's

Trends in national spending for R&D can be cheering or a cause for concern, depending on your perspective. The total U.S. R&D effort has been expanding—measured in current dollars—at an 11- to 12%-a-year clip for the past few years. And the National Science Foundation is looking for another 11% rise in 1981, to a total it estimates at $66.7 billion. That's double what was spent six years ago.

That means, too, that even during a period of rampant inflation, R&D is making at least a little headway, in real terms. But not much. After adjusting for inflation, R&D spending is likely to grow at an annual rate of only 1% this year and next. That's a stronger performance than occurred during the late 1960's and early 1970's, when real spending was drifting lower about 1% a year. But it doesn't stack up very favorably against the 1975–79 period, when a real growth of better than 4% a year was under way.

Whatever growth has been taking place, moreover, can be credited to the private sector of the economy. Federal spending, in constant-dollar terms, will show little change this year and may be down slightly next year. Meanwhile, nonfederal funding of R&D, more than 90% of which is from industry, is expected to be up 2 to 3% a year.

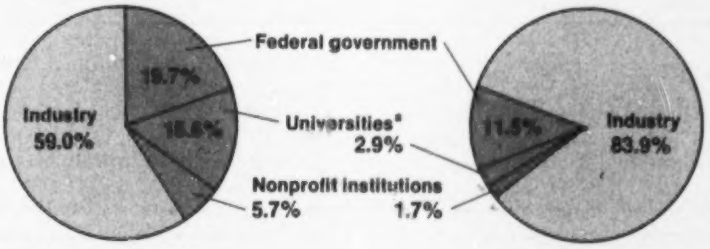
Most R&D is carried out by industry but basic research is done largely in universities



1979 total R&D spending = $54.3 billion

1979 basic research spending = $7.3 billion

Applied research and development is focused in industrial labs



1979 applied research spending = $12.2 billion

1979 development spending = $34.8 billion

a Includes associated federally funded research and development centers. **Source:** National Science Foundation

TRENDS IN R&D: Nonfederal outlays represent a growing share of the total

% of total outlays	1980a	1979a	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1968	1967	1966	1965	1964	1963	1962	1961
Federal	49%	49%	50%	51%	51%	51%	51%	53%	55%	56%	57%	58%	61%	62%	64%	65%	66%	66%	64%	65%
Defense related	24	24	24	25	26	27	28	31	32	32	33	34	35	35	33	33	37	41	48	50
Space related	8	7	7	8	8	7	7	7	8	9	10	11	13	14	19	21	19	14	7	6
Civilian related	17	18	19	18	17	17	16	15	15	15	14	13	13	13	12	11	11	10	10	9
Nonfederal	51	51	50	49	49	49	49	47	45	44	43	42	39	38	36	35	34	34	36	35

Note: Data may not total 100% because of rounding. a Estimated. **Source:** National Science Foundation

SOURCES OF R&D FUNDS: Industry is overtaking government as biggest supplier . . .

$ Billions, current	1981[a]	1980[a]	1979[a]	1978	1977	1976	1975	1974	1973	1972	1971	1970	Annual change	
													1979–80	1970–80
Federal government	$32.0	$29.4	$26.8	$24.1	$21.8	$19.8	$18.2	$16.8	$16.3	$15.8	$14.9	$14.7	10%	7%
Industry	32.2	28.7	25.5	22.4	19.7	17.9	15.8	14.9	13.3	11.7	10.8	10.4	13	11
Universities and colleges	1.5	1.3	1.2	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	8	10
Other nonprofit institutions	1.0	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.3	11	13
TOTAL	**$66.7**	**$60.4**	**$54.3**	**$48.3**	**$43.0**	**$39.0**	**$35.3**	**$32.8**	**$30.6**	**$28.4**	**$26.6**	**$25.9**	11%	9%

a Estimated. **Source:** National Science Foundation

. . . as only its contribution shows growth in constant dollars, this year

$ Billions, constant (1972)	1981[a]	1980[a]	1979[a]	1978	1977	1976	1975	1974	1973	1972	1971	1970	Annual change	
													1979–80	1970–80
Federal government	$16.0	$16.2	$16.2	$15.8	$15.3	$14.9	$14.4	$14.6	$15.5	$15.8	$15.5	$16.1	0%	0%
Industry	16.1	15.8	15.4	14.8	13.9	13.2	12.4	12.8	12.6	11.7	11.3	11.4	3	3
Universities and colleges	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0	3
Other nonprofit institutions	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0	2
TOTAL	**$33.4**	**$33.3**	**$32.8**	**$31.8**	**$30.3**	**$29.2**	**$27.9**	**$28.5**	**$29.1**	**$28.4**	**$27.7**	**$28.4**	2%	2%

a Estimated. **Source:** National Science Foundation

PERFORMERS OF R&D: More than two thirds is done by industry . . .

$ Billions, current	1981[a]	1980[a]	1979[a]	1978	1977	1976	1975	1974	1973	1972	1971	1970	Annual change	
													1979–80	1970–80
Industry	$47.0	$42.4	$37.6	$33.4	$29.9	$27.0	$24.2	$22.9	$21.2	$19.6	$18.3	$18.1	13%	9%
Federal government	8.5	7.8	7.5	6.9	6.1	5.7	5.4	4.8	4.6	4.5	4.2	3.9	4	7
Universities and colleges	6.7	6.1	5.3	4.6	4.1	3.7	3.4	3.0	2.9	2.7	2.5	2.3	15	10
Associated FFRDC's[b]	2.2	2.0	1.8	1.7	1.4	1.1	1.0	0.9	0.8	0.8	0.7	0.7	11	11
Other nonprofit institutions	2.4	2.2	2.0	1.7	1.5	1.4	1.3	1.2	1.0	1.0	0.9	0.9	10	9
TOTAL	**$66.7**	**$60.4**	**$54.3**	**$48.3**	**$43.0**	**$39.0**	**$35.3**	**$32.8**	**$30.6**	**$28.4**	**$26.6**	**$25.9**	11%	9%

a Estimated. b Federally funded research and development centers administered by universities and colleges. **Source:** National Science Foundation

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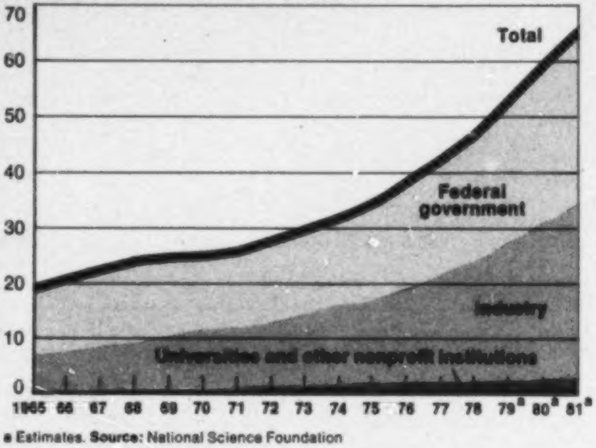
. . . but increases in R&D spending are slight after accounting for inflation

$ Billions, constant (1972)	1981[a]	1980[a]	1979[a]	1978	1977	1976	1975	1974	1973	1972	1971	1970	Annual change	
													1979–80	1970–80
Industry	$23.5	$23.3	$22.7	$22.0	$21.1	$20.2	$19.0	$19.7	$20.1	$19.6	$19.1	$19.8	3%	2%
Federal government	4.3	4.3	4.5	4.5	4.3	4.3	4.3	4.3	4.4	4.5	4.3	4.2	−4	0
Universities and colleges	3.4	3.3	3.2	3.0	2.9	2.8	2.7	2.7	2.8	2.7	2.6	2.6	3	2
Associated FFRDC's[b]	1.1	1.1	1.1	1.1	1.0	0.9	0.8	0.8	0.8	0.8	0.7	0.8	0	3
Other nonprofit institutions	1.2	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	2
TOTAL	**$33.4**	**$33.3**	**$32.8**	**$31.8**	**$30.3**	**$29.2**	**$27.9**	**$28.5**	**$29.1**	**$28.4**	**$27.7**	**$28.4**	2%	2%

a Estimated. b Federally funded research and development centers administered by universities and colleges. **Source:** National Science Foundation

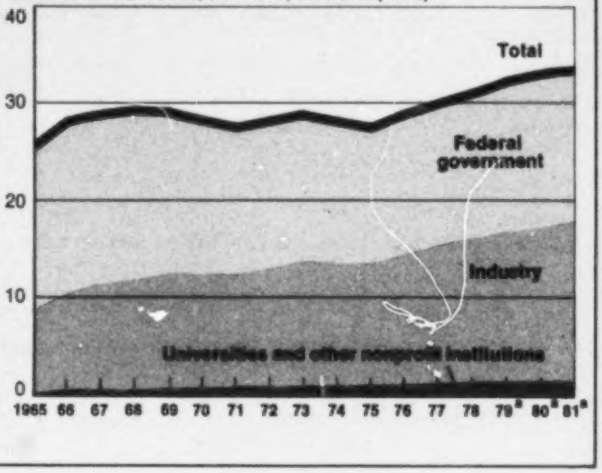
Expenditures for R&D rose steadily during the 1970's . . .

Sources of R&D funds, $ billions, current



. . . but inflation eliminated much of the gain, especially in government spending

Sources of R&D funds, $ billions, constant (1972)



a Estimates. **Source:** National Science Foundation

CHARACTER OF R&D: Development efforts absorb the major share of R&D funds . . .

$ Billions, current	1980a	1979a	1978	1977	1976	1975	1974	1973	1972	1971	1970	Annual change 1979–80	Annual change 1970–80
Basic research	$ 8.2	$ 7.3	$ 6.4	$ 5.5	$ 4.9	$ 4.6	$ 4.2	$ 3.9	$ 3.7	$ 3.6	$ 3.5	12%	9%
Applied research	13.5	12.2	10.9	9.9	9.1	8.0	7.4	6.7	6.1	5.8	5.7	11	9
Development	38.6	34.8	31.1	27.6	25.0	22.8	21.3	20.1	18.6	17.2	16.7	11	9

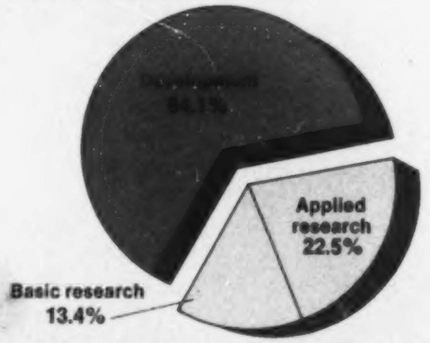
a Estimated. **Source:** National Science Foundation

. . . but this year basic research will show largest gain in spending

$ Billions, constant (1972)	1980a	1979a	1978	1977	1976	1975	1974	1973	1972	1971	1970	Annual change 1979–80	Annual change 1970–80
Basic research	$ 4.5	$ 4.4	$ 4.2	$ 3.9	$ 3.7	$ 3.6	$ 3.7	$ 3.7	$ 3.7	$ 3.7	$ 3.8	2%	2%
Applied research	7.4	7.4	7.1	7.0	6.8	6.3	6.4	6.3	6.1	6.1	6.3	0	2
Development	21.3	21.0	20.4	19.5	18.7	18.0	18.4	19.0	18.6	17.9	18.3	1	2

a Estimated. **Source:** National Science Foundation

Development accounts for most of R&D spending



1979 total R&D spending = $54.3 billion

Source: National Science Foundation

EMPLOYED SCIENTISTS AND ENGINEERS: Chemists account for 6% of total

Thousands	1978	1976	1974
Physical scientists	212.4	227.4	201.4
Chemists	143.7	150.4	133.5
Physicists/ astronomers	51.2	56.6	52.7
Engineers	1268.4	1240.7	1212.6
Chemical	62.0	na	na
Other scientists	992.4	909.1	834.2
TOTAL	2473.2	2377.2	2248.2

na = not available. **Source:** National Science Foundation

SCIENTISTS AND ENGINEERS BY SEX, RACE: Women comprise 11% of chemical labor force

	Total[a]			Labor force[b]						
Thousands, 1978	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**White**	**Black**	**Asian**	**Other races**
Physical scientists	**254.6**	**231.8**	**22.8**	**216.7**	**200.7**	**16.0**	**206.8**	**3.2**	**5.3**	**1.4**
Chemists	173.7	154.7	19.0	146.6	133.4	13.2	139.0	3.1	3.4	1.1
Physicists/ astronomers	61.6	59.3	2.2	52.3	50.9	1.4	50.4	0.1	1.5	0.2
Engineers	**1396.4**	**1374.6**	**21.7**	**1285.0**	**1264.5**	**20.5**	**1234.4**	**10.6**	**26.4**	**13.6**
Chemical	67.9	65.0	2.9	62.8	60.1	2.7	59.9	0.3	1.6	0.9
Other scientists	**1090.4**	**868.9**	**221.6**	**1005.9**	**805.2**	**200.7**	**952.4**	**25.8**	**19.6**	**8.2**
TOTAL	**2741.4**	**2475.3**	**266.1**	**2507.6**	**2270.4**	**237.2**	**2393.6**	**39.6**	**51.3**	**23.2**

a Includes both those in or outside the labor force. b Includes both those employed or unemployed. **Source:** National Science Foundation

SCIENTISTS AND ENGINEERS BY AGE: Half of men and three fourths of women are under 40

Thousands, 1978	**Total**	**24 and under**	**25–29**	**30–34**	**35–39**	**40–44**	**45–49**	**50–54**	**55–59**	**60–64**	**65–69**	**70 and over**
Chemists	**173.7**	**20.2**	**26.6**	**18.6**	**21.2**	**19.3**	**17.7**	**16.4**	**14.7**	**9.6**	**6.5**	**2.9**
Men	154.7	15.8	22.1	15.5	19.0	18.2	16.5	15.4	14.0	9.3	6.0	2.9
Women	19.0	4.4	4.5	3.1	2.2	1.0	1.2	1.0	0.7	0.3	0.5	0.1
Chemical engineers	**67.9**	**5.9**	**12.4**	**9.8**	**8.1**	**6.7**	**5.5**	**6.5**	**6.8**	**4.3**	**1.4**	**0.7**
Men	65.0	5.0	10.9	9.3	8.0	6.7	5.5	6.5	6.8	4.3	1.4	0.7
Women	2.9	0.8	1.5	0.5	0.1	a	a	a	a	a	a	a
Total scientists and engineers	**2741.4**	**212.6**	**436.1**	**426.3**	**365.4**	**303.1**	**283.9**	**262.8**	**200.9**	**121.7**	**75.6**	**52.9**
Men	2475.3	147.6	367.5	380.0	338.9	286.6	270.1	252.8	192.5	117.8	71.5	49.8
Women	266.1	64.8	68.6	46.3	26.6	16.5	13.8	10.0	8.4	3.9	4.1	3.2

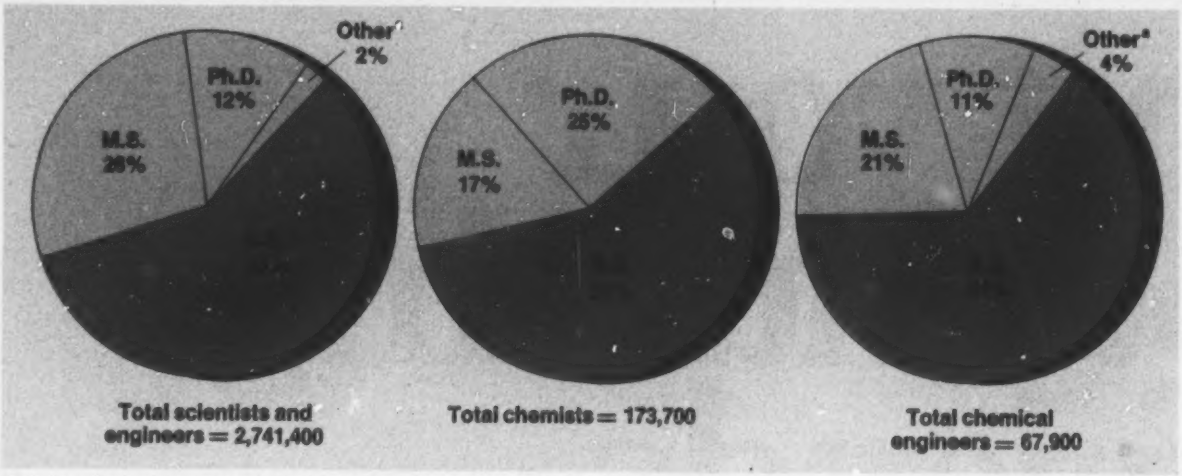
a Too few cases to estimate. **Source:** National Science Foundation

EMPLOYED CHEMISTS AND CHEMICAL ENGINEERS: Most work for industry and do R&D

% in category, 1978	**Total chemists**	**Men chemists**	**Women chemists**	**Women as a % of total chemists**	**Total Ch.E.'s**	**Men Ch.E.'s**	**Women Ch.E.'s**	**Women as a % of total Ch.E.'s**
Employer								
Industry	65.0%	65.3%	60.6%	8.1%	90.2%	89.9%	92.0%	4.2%
Educational institutions	21.0	20.8	23.8	9.8	4.3	4.3	4.0	3.8
Nonprofit organizations	2.8	2.8	4.1	12.5	1.1	1.2	a	a
Federal government	5.7	5.6	5.7	8.8	2.9	2.9	4.0	5.6
Military	0.3	0.3	a	a	0.2	0.2	a	a
State and local governments	3.0	3.0	3.3	9.3	0.5	0.6	a	a
Other government agencies	1.8	1.8	2.5	11.5	0.5	0.6	a	a
Others	0.4	0.4	a	a	0.3	0.3	a	a
Work activity								
Basic research	13.6	12.1	29.5	18.8	1.8	1.9	3.8	9.1
Applied research	15.9	15.7	18.0	9.8	5.7	5.7	3.8	2.9
Development	15.0	15.2	12.3	7.1	37.3	38.0	19.2	2.2
Management or administration of R&D	13.2	14.2	3.3	2.1	9.1	8.8	15.4	7.1
Management or administration of other than R&D	8.4	8.9	4.1	4.2	10.5	11.0	a	a
Teaching	9.9	10.0	9.0	7.9	3.2	3.4	a	a
Consulting	1.6	1.6	1.6	8.7	3.7	3.7	a	a
Production and inspection	17.6	17.9	15.6	7.6	21.4	20.3	42.3	8.3
Other activities	4.8	4.4	6.6	12.1	7.3	7.2	16.5	6.5

a Too few cases to estimate. **Source:** National Science Foundation

Highest degree for most scientists and engineers is B.S.



[a] Includes professional, associate, and other degrees. **Source:** National Science Foundation

EMPLOYED CHEMISTS AND CHEMICAL ENGINEERS, ACTIVITY BY EMPLOYER: Development work is the biggest function for those in industry

				Management or administration					
% in work activity, 1978	**Basic research**	**Applied research**	**Development**	**R&D**	**Other than R&D**	**Teaching**	**Consulting**	**Production and inspection**	**Other activities**
Chemists									
Industry	4.3%	18.5%	21.8%	17.9%	9.8%	0.3%	1.8%	20.7%	4.9%
Educational institutions	37.2	4.4	1.4	2.0	3.4	45.1	0.3	2.4	3.8
Nonprofit organizations	40.0	22.5	5.0	7.5	5.0	2.5	5.0	10.0	2.5
Federal government	30.0	30.0	8.8	12.5	6.3	a	a	8.8	3.6
Military	50.0	25.0	a	a	25.0	a	a	a	a
State and local governments	2.3	11.6	a	4.7	18.6	2.3	2.3	51.2	7.0
Other government agencies	3.8	23.1	a	7.7	15.5	a	11.5	30.8	7.6
Others	a	20.0	40.0	20.0	a	a	a	a	20.0
Chemical engineers									
Industry	0.5	4.9	39.8	9.6	9.5	0.5	4.0	23.3	7.9
Educational institutions	23.2	3.8	11.5	a	a	61.5	a	a	a
Nonprofit organizations	a	28.6	14.3	28.5	a	a	14.3	a	14.3
Federal government	5.5	16.7	16.7	5.5	50.0	a	a	a	5.6
Military	a	a	a	a	a	a	a	100.0	a
State and local governments	a	a	a	a	33.3	a	a	66.7	a
Other government agencies	33.3	33.3	a	a	33.3	a	a	a	a
Others	a	a	50.0	a	50.0	a	a	a	a

a Too few cases to estimate. **Source:** National Science Foundation

ORIGIN OF PAPERS IN *CHEMICAL ABSTRACTS*:[a] U.S. leads world in chemical publications

	Number of papers							
	1979	**1978**	**1977**	**1976**	**1975**	**1974**	**1973**	**1972**
U.S.	101,772	96,420	89,974	81,517	81,697	70,841	71,029	76,815
U.S.S.R.	70,563	74,112	80,765	76,677	77,916	68,665	66,479	65,839
U.K.	22,017	22,335	21,626	20,273	20,192	16,316	16,235	17,932
Japan	35,825	34,335	28,646	24,722	23,153	20,017	20,234	21,934
West Germany	22,051	22,498	20,948	18,634	18,086	14,929	14,294	15,937
France	15,393	14,575	14,630	13,286	13,139	11,426	11,509	12,065
Others	102,988	98,799	91,260	82,804	83,086	69,741	69,698	69,153
TOTAL	**370,609**	**363,074**	**347,849**	**317,913**	**317,269**	**271,935**	**269,478**	**279,675**

[a] "Origin" refers to the country in which the reported work was performed. **Source:** Chemical Abstracts Service

ABSTRACTS OF PAPERS IN *CHEMICAL ABSTRACTS:* Biochemistry is leading category

% IN EACH GROUP	1979	1978	1977	1976	1975	1974	1973	1972
Biochemistry	38.8%	38.3%	37.9%	38.8%	39.4%	36.2%	35.9%	35.6%
Physical and analytical chemistry[a]	28.9	27.4	27.9	27.5	29.6	29.7	31.0	32.2
Applied chemistry and chemical engineering	19.4	20.8	19.7	18.8	15.5	18.4	16.7	15.7
Organic chemistry	7.6	8.0	8.8	8.7	9.0	9.4	10.0	9.5
Macromolecular chemistry	5.3	5.5	5.7	6.2	6.5	6.3	6.4	7.0
% OF ALL BIOCHEMISTRY ABSTRACTS								
Mammalian biochemistry	17.1%	17.2%	17.7%	16.3%	15.3%	16.6%	13.7%	13.0%
Pharmacodynamics	11.9	12.3	12.0	12.0	12.0	11.1	11.1	12.0
Toxicology	7.4	7.5	6.2	6.4	6.6	5.6	5.9	5.5
General biochemistry	7.0	6.5	7.0	7.1	7.5	7.3	7.9	7.4
Enzymes	6.4	5.7	6.1	6.4	7.4	6.4	5.8	6.6
Others	50.2	50.8	51.0	51.8	51.2	53.0	55.6	55.5
% OF ALL PHYSICAL AND ANALYTICAL CHEMISTRY ABSTRACTS								
Nuclear chemistry	25.1%	20.7%	21.1%	19.7%	20.0%	15.8%	19.0%	18.1%
Spectra	17.0	17.0	18.1	17.8	17.2	18.2	16.8	17.5
Electric phenomena	11.4	10.9	10.5	10.5	10.3	11.4	10.8	11.2
Crystallization and crystal structure	8.2	9.2	8.9	9.7	9.6	10.1	10.2	10.1
General physical chemistry	6.6	6.6	6.8	7.0	6.8	6.4	7.2	6.9
Analytical chemistry	5.6	7.2	5.8	6.6	6.1	7.4	6.9	6.8
Others	25.8	26.4	28.8	28.7	30.0	30.7	29.1	29.4
% OF ALL APPLIED CHEMISTRY AND CHEMICAL ENGINEERING ABSTRACTS								
Metals and alloys	23.6%	24.0%	24.2%	27.8%	24.4%	27.9%	24.2%	26.6%
Water, wastes, and pollution	20.8	20.8	23.2	18.6	15.2	18.2	15.6	14.8
Mineralogical and geological chemistry	15.8	16.8	13.4	17.6	17.5	17.6	20.2	19.8
Fossil fuels, derivatives, and related products	7.8	8.2	9.2	6.0	9.8	4.0	8.0	7.3
Unit operations and processes	6.1	6.4	5.8	4.8	5.3	5.6	7.8	7.0
Others	25.9	23.8	24.2	25.2	27.8	26.7	24.2	24.5
% OF ALL ORGANIC CHEMISTRY ABSTRACTS								
Physical organic chemistry	38.8%	36.8%	41.3%	38.4%	40.8%	37.3%	37.2%	35.6%
Heterocyclic compounds	16.0	17.5	17.0	17.4	16.4	17.3	17.8	19.5
Organometallic and organometalloidal compounds	8.5	8.9	8.5	8.7	8.4	8.2	7.8	8.6
Aromatic compounds	8.2	8.6	8.5	8.0	8.7	9.4	10.0	10.1
Aliphatic compounds	6.0	6.9	5.9	6.5	6.3	7.1	7.1	5.6
Carbohydrates	6.0	5.2	4.6	5.1	4.9	5.5	5.6	5.2
Others	16.5	16.1	14.2	15.9	14.5	15.2	14.5	15.4
% OF ALL MACROMOLECULAR CHEMISTRY ABSTRACTS								
Plastics manufacture and uses	27.8%	28.1%	27.5%	26.8%	23.3%	23.1%	24.9%	24.0%
Synthetic high polymers	26.3	25.6	26.5	28.3	30.6	30.6	27.7	26.5
Cellulose, lignin, paper, and other wood products	11.1	10.6	10.0	9.1	9.2	9.2	9.8	9.2
Textiles	10.1	12.1	11.0	11.1	10.2	9.8	11.0	13.3
Coatings, inks, and related products	8.1	7.5	7.5	7.6	7.3	8.1	8.1	7.7
Elastomers, including natural rubber	7.6	8.0	8.5	8.6	9.2	10.4	9.2	9.7
Others	9.0	8.1	9.0	8.5	10.2	8.8	9.3	9.6

[a] Includes inorganic chemistry. **Source:** Chemical Abstracts Service

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U.S. PATENTS: Larger share goes to foreigners

	1979[a]	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969
U.S.[b]	30,605	40,979	41,383	44,162	46,603	50,643	51,501	51,515	55,988	47,073	50,395
Foreign[c]	18,248	25,123	23,886	26,074	25,291	25,632	22,638	23,293	22,328	17,354	17,162
TOTAL	**48,853**	**66,102**	**65,269**	**70,236**	**71,994**	**76,275**	**74,139**	**74,808**	**78,316**	**64,427**	**67,557**
% Foreign	**37.4%**	**38.0%**	**36.6%**	**37.1%**	**35.3%**	**33.6%**	**30.5%**	**31.1%**	**28.5%**	**26.9%**	**25.4%**

[a] Patent figures were low in 1979 because the Patent & Trademark Office was short of funds to print patents it might otherwise have issued. [b] U.S. patents granted to U.S. residents. [c] U.S. patents granted to residents of foreign countries. **Source:** Patent & Trademark Office

R&D

SECTION 2 Federal government

Federal R&D outlays to rise 4% this year

Support of chemical research will be 11% higher, thanks largely to increases in energy and environmental projects

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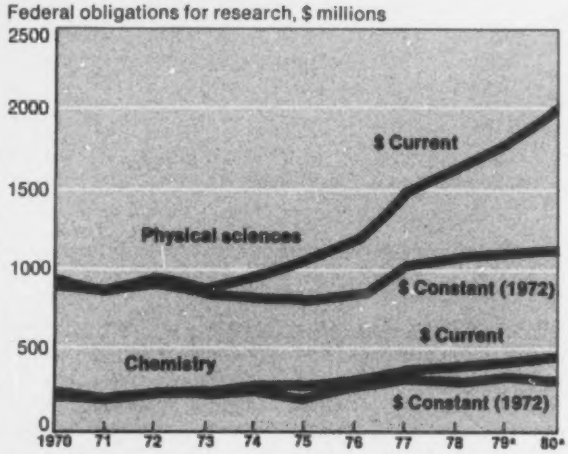
FEDERAL OBLIGATIONS FOR R&D: Most funds go for defense, energy, space, and health

Department or agency	Total R&D ($ millions)				
	1980[a]	1979[a]	1978	1977	1976
Agriculture	$ 663.7	$ 666.9	$ 621.3	$ 547.0	$ 462.4
Science & Education Administration	518.5	518.4	483.0	426.2	355.5
Commerce	321.9	319.1	283.7	244.7	228.9
National Bureau of Standards	73.4	70.2	58.3	53.2	47.4
Defense	13,879.7	13,001.5	11,553.6	10,963.4	9,654.7
Army	3,044.8	2,775.6	2,548.9	2,441.9	2,013.7
Navy	4,527.9	4,618.2	3,998.4	3,817.4	3,328.0
Air Force	5,220.9	4,679.1	4,262.3	4,031.1	3,726.6
Energy	4,658.8	4,688.5	4,244.8	3,536.2	2,498.9[b]
Health, Education & Welfare	3,725.8	3,665.4	3,207.3	2,787.3	2,545.9
National Institutes of Health	2,961.4	2,960.6	2,580.9	2,243.9	2,022.6
Interior	417.3	435.0	385.2	296.3	314.2
Geological Survey	178.2	174.0	159.9	128.9	119.2
Environmental Protection Agency	435.6	400.4	384.6	295.5	259.1
National Aeronautics & Space Administration	4,540.0	4,392.3	3,875.4	3,703.4	3,446.8
National Science Foundation	910.1	818.9	748.8	697.0	609.3
Tennessee Valley Authority	64.0	58.2	31.5	26.5	18.7
Others	1,116.0	1,129.8	1,078.1	831.8	719.7
TOTAL	$30,732.9	$29,576.0	$26,414.3	$23,929.1	$20,758.6

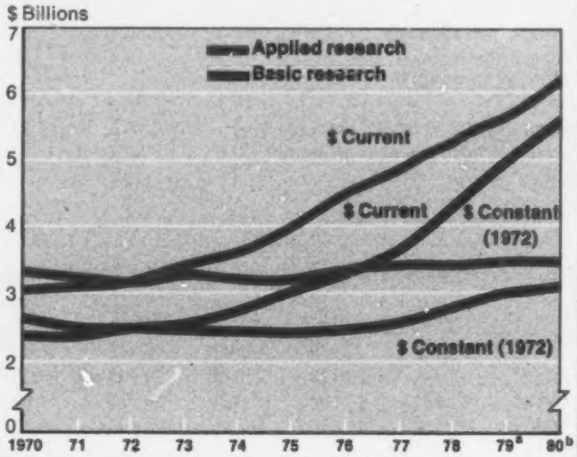
Note: Fiscal years. a Estimated. b For Energy Research & Development Administration. **Source:** National Science Foundation

Federal outlays for chemistry level off in constant dollars



a Estimates **Note:** Fiscal years. **Source:** National Science Foundation

Federal support of basic research has outpaced inflation since 1975



a Preliminary. b Estimates. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR RESEARCH: Health and defense get most support

Department or agency, $ millions	1980[a] Basic research	1980[a] Applied research	1979[a] Basic research	1979[a] Applied research	1978 Basic research	1978 Applied research	1977 Basic research	1977 Applied research	1976 Basic research	1976 Applied research
Agriculture	$ 267.6	$ 368.2	$ 251.9	$ 385.6	$ 242.7	$ 351.8	$ 204.5	$ 319.6	$ 171.4	$ 270.9
Science & Education Administration	232.0	263.5	214.7	279.6	207.9	253.2	174.0	234.3	144.8	196.2
Commerce	28.8	199.4	26.6	189.6	23.9	166.9	23.2	153.0	22.3	133.4
National Bureau of Standards	10.7	46.8	8.6	45.1	5.9	42.6	6.9	38.0	5.8	31.7
Defense	436.9	1975.7	378.4	1774.3	319.1	1622.1	294.8	1746.6	248.4	1539.3
Army	73.6	429.1	59.9	375.6	54.5	359.8	58.6	374.9	39.0	267.4
Navy	152.8	295.3	151.8	293.3	130.3	271.7	115.3	262.6	95.9	219.0
Air Force	122.2	683.4	104.9	636.0	95.1	590.6	85.3	750.0	81.6	740.0
Energy	548.4	719.5	471.6	711.5	440.5	661.7	389.5	501.8	345.8[b]	400.7[b]
Health, Education & Welfare	1581.5	1635.9	1561.4	1580.1	1292.3	1448.4	757.2	1676.5	652.4	1510.5
National Institutes of Health	1434.5	1132.4	1428.6	1133.2	1181.1	1051.5	670.5	1317.6	586.6	1193.3
Interior	161.4	208.0	165.4	209.3	145.7	164.1	128.9	108.6	113.3	127.2
Geological Survey	137.3	40.8	138.0	36.1	126.1	33.8	105.6	23.3	98.5	20.7
Environmental Protection Agency	16.9	297.4	9.4	257.8	6.0	246.7	8.3	197.0	13.7	141.7
National Aeronautics & Space Administration	599.2	1037.8	531.2	963.9	479.7	865.4	413.8	792.3	293.2	929.6
National Science Foundation	828.3	72.8	741.1	70.0	678.0	65.5	624.9	63.4	523.6	72.1
Tennessee Valley Authority	4.3	20.2	4.0	19.4	3.8	9.7	3.5	19.3	—	16.5
Others	64.3	520.8	64.1	522.6	67.4	447.5	45.5	369.0	41.4	305.9
TOTAL	$4537.6	$7055.7	$4205.1	$6684.1	$3699.1	$6051.8	$2894.1	$5947.1	$2425.5	$5447.8

Note: Fiscal years. a Estimated. b For Energy Research & Development Administration. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR SCIENTIFIC DISCIPLINES: A third go to life sciences

$ Millions for research only	1980[a]	1979[a]	1978	1977	1976	Annual change 1979–80	Annual change 1976–80
Physical sciences	$ 2,064	$ 1,847	$1683	$1511	$1221	12%	14%
Chemistry	479	432	416	411	325	11	10
Physics	1,148	1,069	965	841	679	7	14
Life sciences	3,093	3,896	3430	3019	2646	2	11
Environmental sciences	1,289	1,180	1050	921	770	9	14
Mathematics and computer sciences	316	276	236	176	153	14	20
Engineering	2,795	2,659	2446	2426	2378	5	4
Chemical	154	137	153	107	91	12	14
Metallurgy and materials	327	324	295	314	296	1	3
Other sciences	1,136	1,031	906	788	705	10	13
TOTAL	$11,593	$10,889	$9751	$8841	$7873	6%	10%

Note: Fiscal years. a Estimated. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR DEVELOPMENT: Department of Defense supplies most money

Department or agency	Development ($ millions) 1980[a]	Development ($ millions) 1979[a]	Development ($ millions) 1978	Development ($ millions) 1977	Development ($ millions) 1976
Agriculture	$ 27.9	$ 29.4	$ 26.8	$ 22.9	$ 20.2
Science & Education Administration	23.0	24.1	21.8	18.0	14.5
Commerce	93.7	102.9	90.9	68.6	73.1
National Bureau of Standards	16.0	16.5	9.8	8.3	9.9
Defense	11,467.2	10,848.8	9,612.4	8,922.0	7,867.0
Army	2,542.1	2,340.1	2,134.6	2,008.5	1,707.2
Navy	4,079.8	4,173.1	3,596.4	3,439.4	3,013.1
Air Force	4,415.3	3,938.2	3,576.6	3,195.8	2,905.0
Energy	3,390.9	3,505.3	3,142.6	2,645.0	1,752.4[b]
Health, Education & Welfare	508.4	523.9	466.5	353.6	383.0
National Institutes of Health	394.5	398.8	348.3	255.8	242.7
Interior	47.9	60.3	75.5	58.7	73.7
Environmental Protection Agency	121.3	133.1	132.0	90.2	103.7
National Aeronautics & Space Administration	2,903.0	2,897.2	2,530.2	2,497.3	2,224.0
National Science Foundation	9.0	7.9	5.3	8.7	13.5
Tennessee Valley Authority	39.5	34.8	18.0	3.6	2.2
Others	530.8	543.2	563.2	417.3	372.5
TOTAL	$19,139.6	$18,686.8	$16,663.4	$15,087.9	$12,885.3

Note: Fiscal years. a Estimated. b For Energy Research & Development Administration. **Source:** National Science Foundation

OBLIGATIONS FOR PHYSICAL SCIENCES: Chemistry gets biggest support for energy work

	Federal obligations ($ millions)									
	1980^a		1979^a		1978		1977		1976	
Department or agency	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry
Agriculture	$ 50.5	$ 46.1	$ 51.6	$ 47.0	$ 52.1	$ 47.8	$ 63.4	$ 53.8	$ 53.1	$ 44.9
Science & Education Administration	45.5	42.7	46.2	43.4	47.1	44.4	58.6	50.9	48.6	42.5
Commerce	41.3	10.8	37.3	9.2	32.5	8.2	27.8	9.5	22.8	7.1
National Bureau of Standards	35.8	9.6	31.1	7.9	27.5	7.1	24.7	7.8	22.8	7.1
Defense	452.3	78.7	401.3	78.0	358.4	71.3	289.3	90.9	210.6	46.9
Army	98.4	35.2	91.2	36.5	84.2	30.1	82.9	62.5	57.7	25.6
Navy	108.4	16.9	108.7	16.9	100.6	17.8	95.3	15.3	71.7	11.1
Air Force	106.0	26.3	107.4	23.8	94.4	22.7	30.9	11.8	27.7	9.3
Energy	717.2	89.4	650.7	70.6	615.8	76.1	552.8	76.3	475.4^b	76.5^b
Health, Education & Welfare	67.0	60.3	66.6	59.9	58.3	52.5	54.0	49.3	44.6	43.1
National Institutes of Health	65.9	59.2	65.8	59.1	57.1	51.2	53.1	48.3	44.5	43.0
Interior	22.2	17.9	19.6	15.4	18.9	15.2	13.8	11.2	11.5	9.7
Geological Survey	15.4	12.9	11.5	9.0	13.2	11.1	9.4	7.9	9.0	7.5
Environmental Protection Agency	92.2	86.5	74.8	70.0	70.7	67.8	50.2	46.0	49.7	45.7
National Aeronautics & Space Administration	362.1	8.0	310.0	7.5	264.8	9.3	264.2	11.8	197.1	5.3
National Science Foundation	241.3	74.2	218.7	66.2	195.7	60.3	184.2	57.7	148.0	43.1
Tennessee Valley Authority	6.2	6.2	6.0	6.0	5.4	5.4	4.4	4.4	1.8	1.8
Others	11.3	1.3	12.3	1.9	10.8	1.7	6.5	0.3	6.0	0.5
TOTAL	$2063.6	$479.4	$1846.9	$431.7	$1683.4	$415.6	$1510.6	$411.2	$1220.6	$324.6

Note: Fiscal years. a Estimated. b For Energy Research & Development Administration. **Source:** National Science Foundation

BASIC RESEARCH: NSF is biggest backer of basic chemistry

	Federal obligations ($ millions)									
	1980^a		1979^a		1978		1977		1976	
Department or agency	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry
Agriculture	$ 24.6	$ 22.7	$ 24.1	$ 22.2	$ 2.54	$ 23.6	$ 27.5	$ 23.9	$ 21.5	$ 18.5
Science & Education Administration	22.4	21.0	21.8	20.5	23.2	21.9	25.5	22.6	19.6	17.3
Commerce	11.0	1.9	8.8	1.6	6.6	1.0	8.2	2.8	4.8	1.3
National Bureau of Standards	9.9	1.8	7.8	1.4	5.7	0.9	5.7	1.6	4.8	1.3
Defense	109.9	26.2	91.5	23.2	73.1	20.9	72.2	25.3	52.2	12.9
Army	12.7	5.1	10.0	4.0	9.3	3.7	14.2	9.6	5.2	2.5
Navy	43.2	9.7	43.0	9.7	37.9	8.2	33.1	7.2	28.0	5.1
Air Force	26.3	11.3	23.3	9.2	22.5	9.0	21.2	8.4	16.4	5.3
Energy	384.6	64.4	345.0	53.4	325.4	47.9	293.8	61.7	267.4^b	53.8^b
Health, Education & Welfare	40.1	36.3	39.8	36.0	32.9	29.8	35.3	33.6	33.6	33.3
National Institutes of Health	39.7	36.0	39.6	35.8	32.7	29.6	34.4	32.7	33.5	33.3
Interior	13.8	10.7	15.4	12.3	12.9	10.2	9.4	7.4	7.3	6.1
Geological Survey	8.5	7.0	8.8	7.4	8.9	7.7	6.8	5.8	6.3	5.3
Environmental Protection Agency	5.2	4.5	2.6	2.2	1.7	1.3	1.5	1.1	4.1	3.8
National Aeronautics & Space Administration	333.5	7.7	283.0	7.2	243.1	8.9	239.6	10.3	182.9	4.7
National Science Foundation	233.7	70.1	208.6	61.1	189.8	56.7	179.2	54.4	143.5	40.6
Tennessee Valley Authority	2.6	2.6	2.5	2.5	2.4	2.4	2.3	2.3	—	—
Others	9.5	1.0	10.1	1.5	9.1	1.5	4.8	0.2	4.3	0.1
TOTAL	$1168.5	$248.1	$1031.4	$223.2	$922.4	$204.2	$873.8	$223.0	$721.6	$175.1

Note: Fiscal years. a Estimated. b For Energy Research & Development Administration. **Source:** National Science Foundation

APPLIED RESEARCH: Most growth for chemistry comes in environmental and energy work

Department or agency	Federal obligations ($ millions)									
	1980[a]		1979[a]		1978		1977		1976	
	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry
Agriculture	$ 25.9	$ 23.4	$ 27.4	$ 24.8	$ 26.7	$ 24.3	$ 36.0	$ 29.9	$ 31.6	$ 26.4
Science & Education Administration	23.1	21.7	24.4	22.9	23.8	22.5	33.1	28.4	29.0	25.2
Commerce	30.3	8.8	28.4	7.7	25.9	7.2	19.6	6.7	18.0	5.8
National Bureau of Standards	25.9	7.8	23.3	6.5	21.8	6.2	19.0	6.1	18.0	5.8
Defense	342.5	52.5	309.9	54.8	285.3	50.4	217.2	65.6	158.4	34.0
Army	85.7	30.0	81.2	32.5	74.9	26.3	66.7	53.0	52.5	23.1
Navy	65.2	7.1	65.7	7.1	62.7	9.6	62.1	8.1	43.7	6.0
Air Force	79.7	15.0	84.0	14.6	71.9	13.8	9.7	3.4	11.3	4.0
Energy	332.5	24.9	305.7	17.2	290.5	28.2	258.9	14.6	208.0[b]	22.7[b]
Health, Education & Welfare	26.9	24.0	26.8	23.9	25.4	22.6	18.7	15.6	11.1	9.8
National Institutes of Health	26.2	23.3	26.2	23.3	24.3	21.6	18.7	15.6	11.0	9.7
Interior	8.4	7.2	4.2	3.1	6.0	5.0	4.4	3.8	4.2	3.6
Geological Survey	6.9	5.9	2.6	1.6	4.3	3.4	2.7	2.1	2.7	2.2
Environmental Protection Agency	87.0	82.0	72.2	67.8	69.1	66.4	48.7	45.0	45.6	42.0
National Aeronautics & Space Administration	28.6	0.3	27.0	0.3	21.7	0.3	24.6	1.4	14.2	0.5
National Science Foundation	7.5	4.1	8.1	5.0	5.9	3.6	5.0	3.3	4.6	2.5
Tennessee Valley Authority	3.6	3.6	3.5	3.5	3.0	3.0	2.1	2.1	1.8	1.8
Others	1.9	0.5	2.3	0.4	1.5	0.4	1.5	0.2	1.5	0.4
TOTAL	$895.1	$231.3	$815.5	$208.5	$761.0	$211.4	$636.7	$188.2	$499.0	$149.5

Note: Fiscal years. a Estimated. b For Energy Research & Development Administration. **Source:** National Science Foundation

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UNIVERSITY RESEARCH: Main federal emphasis is on life sciences

Federal obligations, $ millions	1980[a]	1979[a]	1978	1977	1976	1975	1974	Annual change	
								1979–80	1974–80
Physical sciences	$ 440.9	$ 407.2	$ 366.2	$ 323.8	$ 281.3	$ 270.6	$ 244.4	8%	10%
Chemistry	153.2	138.8	122.8	117.1	99.1	95.0	79.4	10	12
Physics	235.8	220.8	198.9	163.5	147.2	141.7	128.7	7	11
Life sciences	1897.0	1852.4	1606.1	1405.2	1233.6	1140.4	1103.5	2	9
Environmental sciences	272.9	251.1	225.7	205.7	170.7	147.8	131.8	9	13
Mathematics and computer sciences	100.2	90.8	78.9	69.8	67.0	64.6	58.2	10	10
Engineering	287.6	264.4	247.0	249.3	191.9	188.8	157.3	9	11
Chemical	24.6	22.6	27.0	17.5	16.3	15.9	9.9	9	16
Metallurgy and materials	62.6	56.6	48.6	48.0	46.0	43.5	35.3	11	10
Other sciences	295.5	279.8	252.3	228.4	227.5	185.8	187.1	6	8
TOTAL	$3294.1	$3145.7	$2776.2	$2482.2	$2172.0	$1998.0	$1882.3	5%	10%

Note: Fiscal years. a Estimated. **Source:** National Science Foundation

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UNIVERSITY BASIC RESEARCH: Federal funding for chemistry will grow 14% this year

Federal obligations, $ millions	1980[a]	1979[a]	1978	1977	1976	1975	1974	Annual change	
								1979–80	1974–80
Physical sciences	$ 371.1	$ 331.5	$ 296.9	$ 273.8	$ 243.1	$ 234.8	$211.9	12%	10%
Chemistry	130.2	113.9	100.9	101.7	88.1	82.6	67.5	14	12
Physics	192.8	174.3	155.8	135.7	125.2	121.8	112.7	11	9
Life sciences	1164.7	1120.8	925.9	571.1	508.0	455.2	434.0	4	18
Environmental sciences	232.3	211.0	190.2	165.6	127.6	119.1	103.8	10	14
Mathematics and computer sciences	81.2	71.7	63.7	55.7	46.1	42.1	36.5	13	14
Engineering	186.9	165.3	147.1	134.1	109.8	102.8	83.6	13	14
Chemical	11.9	10.3	9.4	9.5	10.2	10.8	6.4	16	11
Metallurgy and materials	57.6	50.2	42.9	41.2	34.9	32.6	27.4	15	13
Other sciences	134.1	119.6	102.3	91.6	78.3	77.7	78.9	12	9
TOTAL	$2170.3	$2019.9	$1726.1	$1291.9	$1112.9	$1031.7	$948.7	7%	15%

Note: Fiscal years. a Estimated. **Source:** National Science Foundation

Federal agencies will have higher R&D budgets next year, with Defense the biggest gainer

DEPARTMENT OF ENERGY R&D BUDGET: Solar energy comes up fast

$ millions	1981 Probable Congressional authorization[a]	1981 Revised Administration request	1980[b]	1979	1978	% change 1980–81[c]
Nuclear	$ 924.3	$ 658.0	$ 864.3	$ 936.0	$ 880.8	7%
Fossil energy	749.8	653.1	741.5	725.4	676.2	1
Solar technology	422.7	414.5	335.6	302.7	216.4	26
Conservation	363.6	268.0	317.1	176.1	159.3	15
Magnetic fusion	277.3	281.3	228.1	215.9	203.9	21
Environmental R&D	272.5	264.8	255.7	266.3	242.5	6
General science, research	239.9	242.2	217.6	193.4	257.1	10
Basic energy sciences	221.8	229.5	196.1	173.0	156.1	13
Materials sciences	88.1	90.4	79.0	71.5	66.7	11
Chemical sciences	60.4	61.2	55.1	48.0	43.3	10
Nuclear sciences	33.1	33.4	30.7	28.1	26.1	8
Other	40.2	44.5	31.3	25.4	20.0	28
Geothermal	127.3	141.2	121.7	116.1	103.7	5
Energy storage systems	72.8	70.1	64.1	56.9	48.5	13
TOTAL	$3672.0	$3222.7	$3341.8	$3163.8	$2945.3	10%

Note: Fiscal years. a C&EN estimate based on recent Senate and House action. b Estimate. c Based on probable Congressional authorization.

NSF BUDGET: A billion dollars for scientific research this year

$ millions	1981 Probable Congressional authorization[a]	1981 Revised Administration request	1980[b]	1979	1978	% change 1980–81[c]
Mathematical and physical sciences	$ 252.5	$ 259.8	$ 226.4	$ 208.9	$ 248.5[d]	11%
Astronomical, atmospheric, earth, and ocean sciences	230.7	235.8	217.9	211.6	211.6	6
Biological, behavioral, and social sciences	180.5	177.9	166.5	154.7	141.9	8
Engineering and applied sciences	135.3	119.6	111.6	109.9	55.1	21
Science education	89.6	75.7	75.7	80.0	73.9	18
Program development and management	59.9	59.8	60.6	54.8	48.7	−1
Antarctic program	59.7	60.4	55.8	51.1	48.5	7
Cross directorate programs	33.0	29.7	25.5	16.9	—	29
Scientific, technological, and international affairs	28.5	27.7	24.1	23.7	28.8	18
Ocean drilling programs	20.7	22.0	19.5	11.6		6
Women in Science programs	7.7	—	—	—	—	—
Special foreign currency program	5.5	5.5	5.5	4.0	5.4	0
TOTAL	$1103.6	$1073.9	$989.3	$927.2	$857.4	11%

Note: Fiscal years. a C&EN estimates based on recent Senate and House action. b Estimate. c Based on probable Congressional authorization. d Includes engineering programs.

DEFENSE R&D BUDGET: Air Force outlays due for a big increase

$ millions	1981 Probable Congressional authorization[a]	1981 Revised Administration request	1980[b]	1979	1978	% change 1980–81[c]
Air Force	$ 7,137.9	$ 7,033.4	$ 4,988.4	$ 4,358.9	$ 4,222.0	43%
Navy	5,113.9	4,865.6	4,564.5	4,464.4	4,054.3	12
Army	3,216.0	3,234.5	2,851.2	2,838.9	2,418.3	13
Defense agencies	1,307.1	1,302.7	1,037.0	892.9	754.3	26
Test and evaluation	42.1	42.1	42.5	27.6	25.0	−1
TOTAL	$16,817.0	$16,478.3	$13,483.6	$12,582.7	$11,473.9	25%

Note: Fiscal years. a C&EN estimates based on recent Senate and House action. b Estimate. c Based on probable Congressional authorization.

NASA R&D BUDGET: Space shuttle gets largest share but no increase

$ millions	1981 Congressional authorization	1981 Revised Administration request	1980[a]	1979	1978	% change 1980–81
Conduct of R&D	$4436.7	$4364.5	$4092.5	$3477.2	$3011.6	8%
Space shuttle	1873.0	1873.0	1871.0	1638.3	1349.2	0.1
Space flight operations	779.5	767.5	446.6	299.7	267.8	74
Space applications	378.7	358.7	364.3	295.2	234.8	4
Physics and astronomy	352.7	346.6	339.2	288.4	224.2	4
Tracking and data acquisition	349.7	349.0	332.4	299.9	276.3	5
Aeronautical research and technology	290.8	275.3	308.3	264.1	228.0	−6
Planetary exploration	179.6	175.3	219.9	183.4	147.2	−18
Space research & technology	115.2	110.2	116.8	107.3	97.7	−1
Expendable launch vehicles	65.7	55.7	36.1	38.7	134.5	84
Life sciences	45.2	39.1	43.8	40.1	38.3	3
Technology utilization	12.6	12.1	12.1	9.1	9.1	4
Energy technology	4.0	4.0	3.0	5.0	7.5	33
Research and program management	1033.1	1033.1	996.2	933.8	889.5	4
Construction of facilities	118.0	120.9	156.1	147.5	162.3	−25
TOTAL	$5587.8	$5517.4	$5244.8	$4558.5	$4063.4	6%

Note: Fiscal years. a Estimate.

EPA R&D BUDGET: Overall change will be modest in fiscal 1981

$ millions	1981 Probable Congressional authorization[a]	1981 Administration request	1980[b]	1979	1978	% change 1980–81[c]
Energy	$105.1	$107.6	$101.4	$112.6	$133.1	4%
Air	70.2	70.2	66.7	52.0	44.6	5
Water quality	64.0	60.0	65.2	65.7	72.4	−2
Toxic substances	34.6	36.9	27.9	16.8	8.9	24
Drinking water	28.5	27.4	22.7	17.6	16.6	26
Solid waste	23.4	26.4	18.2	8.5	7.4	28
Interdisciplinary	21.4	22.8	22.7	19.7	12.8	−6
Pesticides	9.4	9.4	13.0	12.7	12.9	−28
Radiation	3.2	3.2	3.1	1.8	0.8	3
TOTAL	$359.8	$363.9	$340.9	$307.4	$309.6	6%

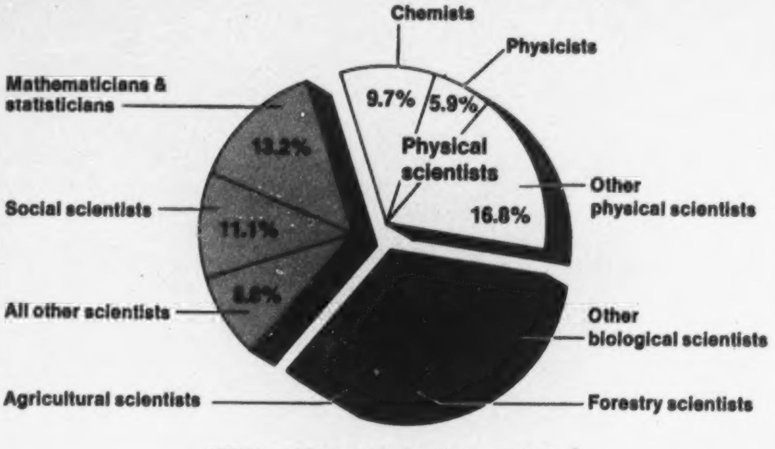
Note: Fiscal years. a C&EN estimate based on recent Senate and House action. b Estimate. c Based on probable Congressional authorization.

NIH BUDGET: Administration seeks little more than is being spent this year

$ millions	1981[a]	1980[b]	1979	1978	1977	% change 1980–81[c]
National Institutes	$3314.8	$3198.9	$2934.8	$2553.1	$2241.1	4%
Cancer	1008.3	1004.2	937.1	873.2	814.2	0.4
Heart, Lung & Blood	548.5	528.9	510.1	447.9	396.8	4
Arthritis, Metabolism & Digestive Diseases	365.7	342.9	302.7	259.8	219.4	7
General Medical Sciences	331.6	312.6	277.3	230.5	204.9	6
Neurological & Communicative Disorders & Stroke	249.9	242.6	212.1	177.4	155.3	3
Allergy & Infectious Diseases	228.5	216.7	191.9	164.2	104.8	5
Child Health & Human Development	217.5	209.8	197.3	149.4	145.4	4
Eye	116.3	113.4	104.8	85.2	63.9	2
Environmental Health Sciences	102.3	88.3	80.6	68.8	51.0	16
Aging	75.4	70.3	56.5	37.1	29.9	7
Dental Research	70.5	69.0	64.4	61.8	55.5	2
Research resources	190.2	174.8	168.7	146.3	137.5	9
National Library of Medicine	46.7	46.6	41.5	36.9	35.1	0.2
Office of the director	36.3	34.7	30.8	29.0	16.6	2
Research facilities	19.4	18.1	30.3	56.8	67.4	7
John E. Fogarty Center	8.8	8.7	9.4	8.5	8.0	1
TOTAL	$3616.2	$3482.0	$3206.3	$2832.9	$2566.6	4%

Note: Fiscal years a Administration request. b Estimate. c Based on Administration request.

Chemists account for almost 10% of all federal scientists



1978 total federal scientists = 84,780[a]

[a] As of October. **Source:** National Science Foundation

SCIENTISTS AND ENGINEERS BY AGENCY: Health and defense employ most chemists

Department or agency	Physical scientists	Chemists	Physicists	Engineers	Chemical engineers	Other scientists	Total scientists and engineers
Defense	8968	1939	3561	54,449	869	10,742	74,159
Army	3252	896	976	19,788	386	4,259	27,299
Navy	3968	685	2021	23,889	249	2,653	30,510
Air Force	1204	296	543	9,484	28	1,286	11,974
Others	544	62	21	1,288	6	2,544	4,376
Veterans Administration	731	660	52	932	0	2,206	3,869
Agriculture	1587	1055	44	2,922	62	20,460	24,969
Health, Education & Welfare	2268	2098	99	498	24	2,822	7,588
Interior	4513	448	80	3,074	83	6,221	13,808
National Aeronautics & Space Administration	1384	92	312	9,154	10	885	11,423
Commerce	3945	364	625	948	19	3,301	8,194
Transportation	159	35	17	5,080	18	699	5,938
Energy	966	315	125	2,634	225	529	4,129
Environmental Protection Agency	1479	605	29	1,868	176	905	4,252
Tennessee Valley Authority	227	109	0	3,214	150	556	3,997
Others	1258	536	25	4,378	29	5,969	11,605

Note: Data as of October 1978. **Source:** National Science Foundation

FEDERAL SCIENTISTS AND ENGINEERS: Total rises after drop in 1973 and 1974

Thousands	1978	1977	1976	1975	1974	1973	1972	1971	1970
Physical scientists	27.5	27.1	27.1	26.7	26.3	26.4	27.4	30.4	29.8
Chemists	8.3	8.0	8.1	8.0	7.8	8.0	8.4	8.3	8.1
Physicists	5.0	5.1	5.3	5.4	5.5	5.6	5.8	5.4	5.4
Engineers	89.2	87.8	87.0	86.6	82.5	84.3	87.0	84.2	83.0
Chemical	1.5	1.4	1.4	1.4	1.4	1.5	1.6	1.5	1.4
Other scientists	57.2	54.3	51.6	50.6	48.8	48.4	50.1	48.7	47.4
TOTAL	173.9	169.2	165.7	163.9	157.6	159.1	164.5	163.3	160.2

Note: As of October of each year. **Source:** National Science Foundation

R&D

SECTION 3 Industry

Industrial R&D expands at an accelerating clip

In the chemical industry, spending on R&D last year increased more than at any time since 1974 to show a gain even after factoring out inflation

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TOTAL FUNDS FOR INDUSTRIAL R&D: Chemical industry's outlays grow better than average

$ Millions	1979[a]	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	Annual change	
												1978–79	1969–79
Chemicals and allied products	$ 4,100	$ 3,598	$ 3,256	$ 3,017	$ 2,727	$ 2,450	$ 2,116	$ 1,932	$ 1,832	$ 1,773	$ 1,660	14%	9%
Industrial chemicals	2,085	1,835	1,685	1,524	1,391	1,299	1,119	1,031	1,009	1,031	1,007	14	8
Drugs	1,475	1,282	1,154	1,091	981	807	698	607	549	485	444	15	13
Other chemicals	540	481	417	401	354	344	299	294	274	257	209	12	10
Other industries	33,550	29,802	26,672	23,980	21,460	20,437	19,133	17,620	16,488	16,294	16,648	13	7
TOTAL	$37,650	$33,400	$29,928	$26,997	$24,187	$22,887	$21,249	$19,552	$18,320	$18,067	$18,308	13%	7%

a C&EN estimates. **Source:** National Science Foundation

FEDERAL FUNDS FOR INDUSTRIAL R&D: Chemical firms get relatively little federal support

$ Millions	1979[a]	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	Annual change	
												1978–79	1969–79
Chemicals and allied products	$ 400	$ 365	$ 300	$ 266	$ 236	$ 214	$ 203	$ 189	$ 184	$ 180	$ 192	10%	8%
Industrial chemicals	380	347	284	249	218	194	183	171	159	158	165	10	9
Drugs and other chemicals	20	18	16	17	18	20	20	18	25	22	27	11	−3
Other industries	12,100	10,937	10,221	9295	8369	8006	7942	7828	7482	7599	8259	11	4
TOTAL	$12,500	$11,302	$10,521	$9561	$8605	$8220	$8145	$8017	$7666	$7779	$8451	11%	4%

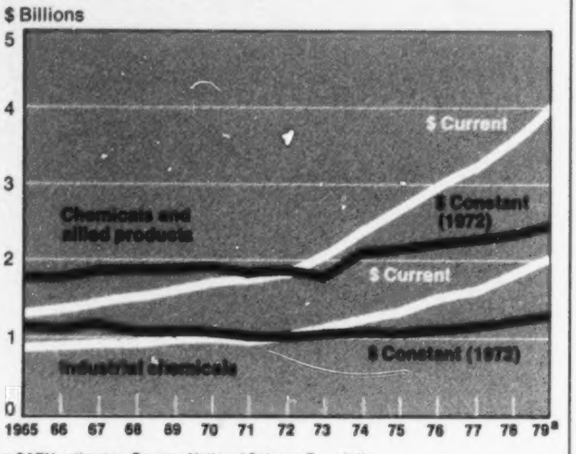
a C&EN estimates. **Source:** National Science Foundation

COMPANY FUNDS FOR INDUSTRIAL R&D: Spending continues to rise

$ Millions	1979[a]	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	Annual change	
												1978–79	1969–79
Chemicals and allied products	$ 3,700	$ 3,232	$ 2,956	$ 2,751	$ 2,490	$ 2,236	$ 1,913	$ 1,741	$ 1,648	$ 1,593	$1468	14%	10%
Industrial chemicals	1,705	1,488	1,402	1,275	1,173	1,105	936	860	850	873	842	15	7
Drugs and other chemicals	1,995	1,744	1,554	1,476	1,317	1,131	977	881	798	720	616	14	12
Other industries	21,450	18,866	16,451	14,685	13,092	12,431	11,191	9,794	9,006	8,695	8389	14	10
TOTAL	$25,150	$22,098	$19,407	$17,436	$15,582	$14,667	$13,104	$11,535	$10,654	$10,288	$9857	14%	10%

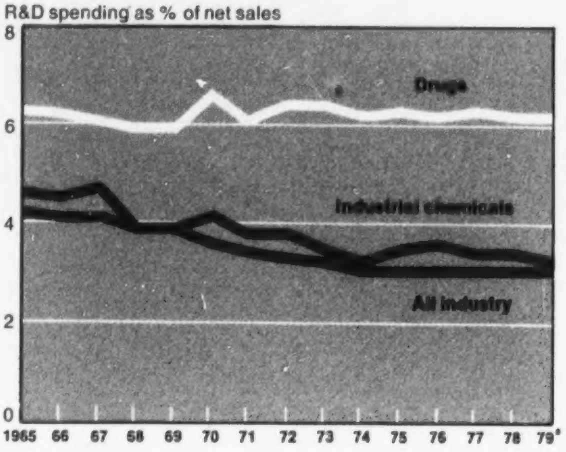
a C&EN estimates. **Source:** National Science Foundation

Chemical industry's R&D makes small progress against inflation



a C&EN estimates. **Source:** National Science Foundation

R&D's share of industry's sales holds relatively steady in recent years



a C&EN estimates. **Source:** National Science Foundation

COMPANY R&D SPENDING: Major chemical firms plan some large increases in 1980

$ Millions	1980[a]	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970
Air Products	$ 27	$ 23	$ 23	$ 24	$ 19	$ 15	$ 11	$ 8	$ 7	$ 7	$ 5
Akzona	29	25	23	20	18	17	16	13	11	10	7
Allied Chemical	75	70	56	51	40	35	31	29	29	31	29
American Cyanamid	140	124	108	96	83	73	64	52	44	43	47
Celanese	100	92	83	77	70	64	58	49	52	51	55
Diamond Shamrock	50	42	36	29	24	20	14	12	12	11	11
Dow Chemical	310[b]	269	232	203	188	167	149	118	105	95	92
Du Pont	480	415	377	367	353	336	344	286	265	259	270
Ethyl Corp.[c]	na	29	25	28	25	19	25	22	20	20	18
W. R. Grace	50	46	41	34	30	30	32	28	22	21	21
Hercules	53	47	40	37	35	30	30	25	24	22	22
Monsanto[d]	195	174	144	132	114	116	87	82	92	87	98
Olin[e]	na	26	25	25	25	24	19	18	16	8	8
Pennwalt[d]	na	24	23	21	19	16	14	13	18	17	18
Rohm & Haas	62	54	49	45	43	45	39	32	25	29	31
Stauffer Chemical	45	37	34	33	29	24	20	17	14	14	14
Union Carbide	174	161	156	156	142	120	94	77	70	78	78
TOTAL[f]	**$1790**	**$1579**	**$1402**	**$1304**	**$1188**	**$1093**	**$989**	**$828**	**$772**	**$758**	**$780**
ANNUAL CHANGE[f]	**13%**	**13%**	**8%**	**10%**	**9%**	**11%**	**19%**	**7%**	**2%**	**−3%**	**1%**

a Planned. b C&EN estimate. c R&D definition narrowed after 1974. d R&D definition narrowed after 1972. e For chemicals only before 1972. f For 14 companies only. na = not available.
Sources: Company data, C&EN estimates

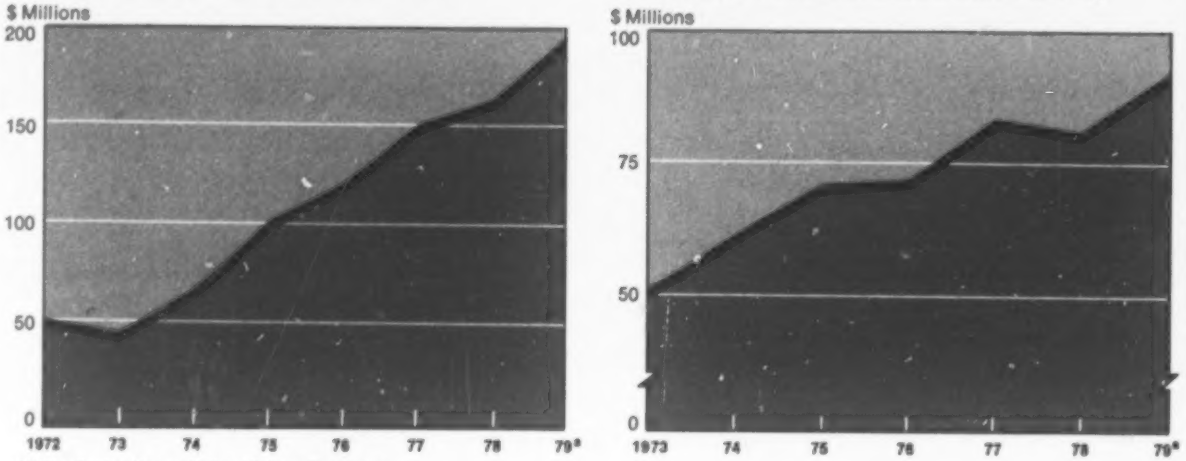
R&D BY U.S. COMPANIES ABROAD: Outlays overseas grow relatively fast for drug firms

$ Millions	1979[a]	1978	1977	1976	1975	1974	Annual change 1978–79	Annual change 1974–79
Chemicals and allied products	**$ 460**	**$ 396**	**$ 332**	**$ 312**	**$ 269**	**$ 208**	16%	17%
Industrial and other chemicals	170	152	133	108	85	82	12	16
Drugs	290	243	199	204	184	126	19	18
Other industries	**1990**	**1770**	**1526**	**1332**	**1172**	**1082**	12	13
TOTAL	**$2450**	**$2166**	**$1858**	**$1644**	**$1441**	**$1290**	13%	14%

a C&EN estimates. **Source:** National Science Foundation

Chemical industry's spending on energy R&D has nearly doubled since 1975 . . .

. . . but outlays for R&D on pollution abatement have increased more slowly



a C&EN estimates. **Source:** National Science Foundation

DRUG R&D: Products for human use account for bulk of spending

R&D expenditures for ethical pharmaceuticals,ª $ millions	1979ᵇ	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	Annual change 1978–79	Annual change 1969–79
Company spending on human-use drugs	**$1495.1**	**$1311.2**	**$1181.8**	**$1067.8**	**$973.5**	**$858.5**	**$752.5**	**$666.8**	**$628.8**	**$565.8**	**$505.8**	14%	11%
In U.S.	1225.2	1089.2	984.1	902.2	828.6	726.0	643.8	600.7	576.5	518.6	464.1	12	10
In foreign countries	269.9	222.0	197.7	164.9	144.9	132.5	108.7	66.1	52.3	46.9	41.7	22	20
Company spending on veterinary-use drugs	**97.7**	**85.8**	**84.3**	**86.5**	**79.0**	**73.7**	**61.9**	**52.5**	**47.9**	**45.1**	**33.8**	14	11
In U.S.	78.1	69.9	68.9	71.4	65.9	58.5	53.7	47.3	43.1	40.0	30.5	12	10
In foreign countries	19.6	15.9	15.4	15.4	13.1	15.2	8.2	5.2	4.8	5.1	3.3	23	20
Government grants and contracts	**6.8**	**7.0**	**10.0**	**9.1**	**9.0**	**8.6**	**10.6**	**6.8**	**7.1**	**7.6**	**9.6**	−3	−4
TOTAL PHARMACEUTICAL R&D SPENDING	**$1599.6**	**$1404.0**	**$1276.1**	**$1163.7**	**$1061.5**	**$940.8**	**$881.3**	**$726.1**	**$683.8**	**$618.5**	**$549.2**	14%	11%

a In the U.S. and abroad for U.S. drug companies and in the U.S. only for U.S.-based subsidiaries of foreign companies. b Budgeted. **Source:** Pharmaceutical Manufacturers Association

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FUNCTION OF DRUG R&D: Clinical studies, screening, and testing are major activities

R&D function	% of total drug R&D spendingª 1978	1977	1976	1975
Clinical evaluation	21.3%	22.5%	23.4%	22.5%
Biological screening and pharmacological testing	18.8	18.7	19.5	20.0
Synthesis and extraction	16.3	17.2	16.6	15.0
Dosage formulation and stability testing	10.1	9.7	9.1	8.4
Toxicology and safety testing	10.0	9.2	8.9	9.0
Process development and quality control	9.2	8.8	9.5	9.8
Regulatory preparation and submission	3.6	3.3	3.3	3.2
Bioavailability studies	2.2	2.3	2.2	2.2
Other	8.5	8.3	7.5	9.9

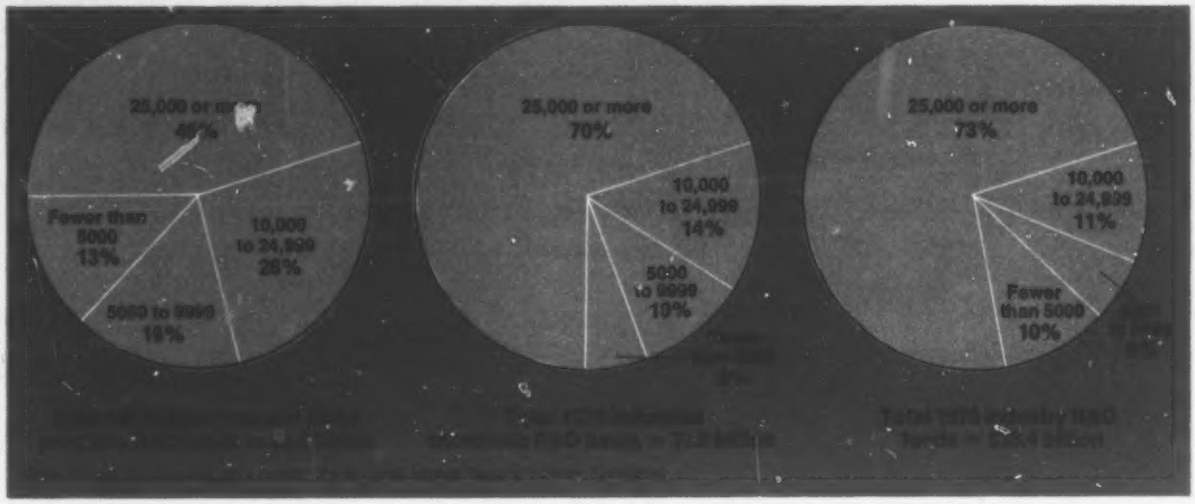
a In U.S. only. **Source:** Pharmaceutical Manufacturers Association

ALLOCATION OF DRUG R&D: Largest share goes to fight infection

Product class	% of total R&D spendingª 1978	1977	1976	1975
Anti-infectives	18.9%	19.2%	19.5%	20.1%
Central nervous system and sense organs	16.8	17.0	16.2	18.0
Cardiovasculars	16.6	15.2	13.2	14.9
Neoplasms, endocrine system and metabolic diseases	16.4	15.7	14.7	15.5
Gastrointestinal and genitourinary system	6.2	6.0	5.8	5.1
Respiratory	4.0	4.0	4.1	5.5
Biologicals	3.2	3.1	3.1	3.0
Dermatologicals	3.1	3.2	2.8	2.8
Vitamins	2.4	2.5	1.5	1.1
Diagnostic (in vivo)	0.5	0.8	1.2	1.2
Other human preparations	5.6	6.3	10.5	6.1
Veterinary preparations	5.9	6.6	7.2	6.5
Veterinary biologicals	0.4	0.4	0.2	0.2

a In U.S. only. **Source:** Pharmaceutical Manufacturers Association

Largest firms account for greatest percentage of R&D spending

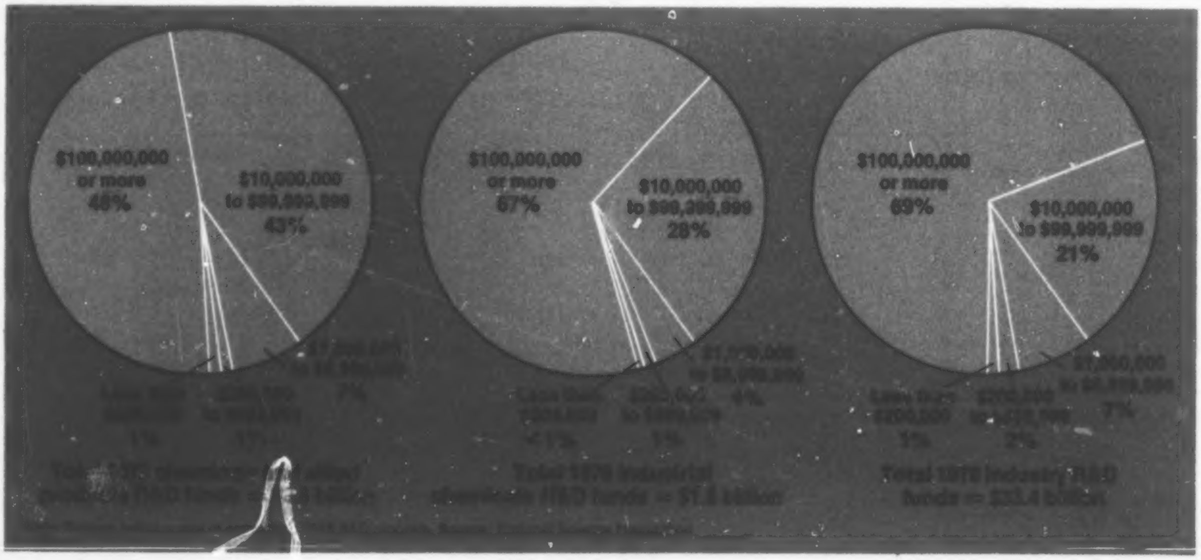


R&D SCIENTISTS AND ENGINEERS IN INDUSTRY: Drug industry employees up considerably

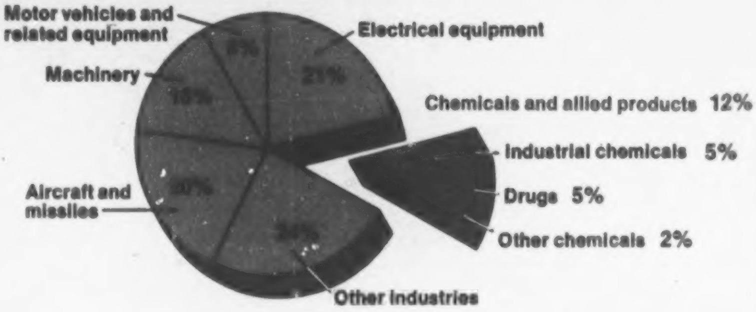
Thousands[a]	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1968
Chemicals and allied products	**49.4**	**47.9**	**46.4**	**44.4**	**45.2**	**41.8**	**40.9**	**41.0**	**42.7**	**40.1**	**38.9**
Industrial chemicals	21.8	21.5	20.6	20.1	21.1	19.1	19.1	19.1	21.8	21.5	22.3
Drugs	19.9	18.9	17.8	16.6	15.6	14.0	13.0	13.1	12.3	11.8	9.8
Other chemicals	7.6	7.4	8.0	7.8	8.5	8.7	8.8	8.8	8.6	6.8	6.8
Other industries	**378.4**	**355.8**	**336.4**	**320.0**	**318.1**	**318.2**	**316.8**	**309.2**	**324.3**	**344.1**	**337.8**
TOTAL	**427.8**	**403.7**	**382.8**	**364.4**	**363.3**	**360.0**	**357.7**	**350.2**	**367.0**	**384.2**	**376.7**

a Full-time equivalent. **Source:** National Science Foundation

Largest share of R&D done by firms spending more than $10 million on their programs



Electrical equipment makers are biggest employer of R&D scientists and engineers[a]



1979 total industrial R&D scientists and engineers[a] = 427,800

[a] Full time equivalent. **Source:** National Science Foundation

R&D SCIENTISTS AND ENGINEERS PER 1000 EMPLOYEES: Ratio high in chemical industry

	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1968
Chemicals and allied products	42	42	40	41	40	39	39	41	39	35	35
Industrial chemicals	39	38	36	38	37	36	34	35	35	32	32
Drugs	63	62	64	59	57	57	60	65	65	48	48
Other chemicals	25	28	28	29	30	29	31	31	30	31	30
TOTAL INDUSTRY	28	27	27	26	25	24	24	26	26	26	26

Source: National Science Foundation

COST PER INDUSTRIAL R&D SCIENTIST OR ENGINEER: Past decade has shown a steady rise

$ Thousands	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1967[a]
Chemicals and allied products	$74.0	$69.1	$66.5	$60.9	$56.3	$51.1	$47.1	$43.7	$42.8	$41.4	$39.8
Industrial chemicals	84.7	80.0	74.7	67.5	63.5	58.6	54.0	49.2	47.5	46.0	43.9
Drugs	66.0	65.0	63.4	60.9	54.3	51.5	46.5	43.2	40.1	40.4	37.1
Other chemicals	64.0	54.2	50.8	43.2	45.3	34.0	33.4	35.5	33.4	29.1	29.8
TOTAL INDUSTRY	$79.5	$76.1	$72.2	$66.5	$63.3	$59.2	$55.3	$51.1	$48.1	$47.5	$44.1

[a] Data for 1968 are not available. **Source:** National Science Foundation

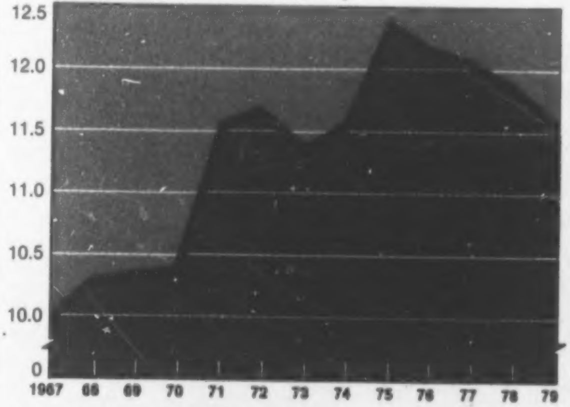
CHEMISTS IN INDUSTRY: Half work for chemical or drug firms

	% of industrial chemists			
Industry	All chemists	B.S.	M.S.	Ph.D.
Chemical	34%	29%	32%	39%
Pharmaceutical	17	14	20	17
Coatings	6	8	5	4
Petroleum	5	5	4	6
Food	5	6	6	4
Metals	3	5	3	2
Rubber	3	4	3	2
Paper	2	2	1	2
Other manufacturing	19	21	19	18
Nonmanufacturing	6	6	7	6

Source: 1980 ACS survey

Share of scientists, engineers in chemical industry has declined slightly since 1975

% of industrial R&D scientists and engineers[a] in the chemicals and allied products industry



[a] Full-time equivalent. **Source:** National Science Foundation

R&D

SECTION 4 Universities and colleges

Federal funds continue to bankroll academic R&D

About two thirds of all R&D done in universities and colleges—and nearly 80% of the R&D in chemistry—is supported by government agencies

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SOURCE OF UNIVERSITY R&D FUNDS: Federal government provides two thirds

$ Millions	1979[a]	1978[a]	1977	1976	1975	1974	1973	1972	1971	1970	1969	Annual change	
												1978–79	1969–79
Federal government	$3600	$3057	$2729	$2512	$2288	$2033	$2038	$1839	$1724	$1648	$1600	18%	8%
State and local governments	450	414	374	364	332	307	295	270	255	219	197	9	9
Industry	190	170	139	123	113	96	85	75	70	61	60	12	12
Institutional funds	700	615	508	444	417	369	319	306	274	243	223	14	12
Other outside sources	400	359	314	284	258	218	201	187	177	165	145	11	11
TOTAL	**$5340**	**$4615**	**$4064**	**$3728**	**$3408**	**$3023**	**$2940**	**$2677**	**$2500**	**$2335**	**$2225**	**16%**	**9%**

Note: Data for fiscal years. a Estimates. **Source:** National Science Foundation

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CHARACTER OF UNIVERSITY R&D SPENDING: Basic research dominates academic work

$ Millions	1979[a]	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	Annual change	
												1978–79	1969–79
Basic research	$3745	$3185	$2787	$2547	$2410	$2153	$2055	$2022	$1914	$1796	$1711	18%	8%
Applied research	1330	1195	1068	1015	851	737	717	544	474	427	407	11	13
Development	265	235	209	168	148	133	168	110	112	112	107	13	9
TOTAL	**$5340**	**$4615**	**$4064**	**$3730**	**$3409**	**$3023**	**$2940**	**$2676**	**$2500**	**$2335**	**$2225**	**16%**	**9%**

Note: Data for fiscal years. a Preliminary. **Source:** National Science Foundation

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FIELDS OF UNIVERSITY R&D SPENDING: Chemistry's share is 4% of total

$ Millions	1979[a]	1978[b]	1977	1976	1975	1974	1973	1972	1970[c]	1968	Annual change	
											1978–79	1968–79
Physical sciences	**$ 560**	**$496.9**	**$428.8**	**$379.6**	**$350.4**	**$333.6**	**$330.4**	**$329.9**	**$307.3**	**$319.7**	13%	5%
Chemistry	210	182.5	163.6	140.3	120.8	115.9	114.1	110.9	102.0	104.7	15	7
Engineering	**690**	**601.1**	**497.3**	**433.2**	**382.2**	**348.0**	**383.6**	**347.3**	**318.8**	**309.1**	15	8
Total R&D spending	**5340**	**4614.9**	**4064.3**	**3727.6**	**3408.4**	**3022.8**	**2939.6**	**2676.5**	**2334.9**	**2148.7**	16	9

Note: Data for fiscal years. a C&EN estimates. b NSF estimates. c Data for 1969 and 1971 not available. **Source:** National Science Foundation

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FEDERALLY FINANCED R&D SPENDING AT UNIVERSITIES: Better-than-average gains lately

$ Millions	1979[a]	1978[b]	1977	1976	1975	1974	1973	1972	1970[c]	1968	Annual change	
											1978–79	1968–79
Physical sciences	**$ 465**	**$393.4**	**$343.3**	**$305.4**	**$285.0**	**$270.2**	**$270.4**	**$267.4**	**$257.8**	**$273.0**	18%	5%
Chemistry	165	138.2	125.2	107.9	92.7	88.7	86.9	84.6	78.9	82.7	19	6
Engineering	**470**	**407.6**	**336.2**	**291.4**	**260.2**	**240.1**	**287.1**	**259.1**	**245.9**	**246.2**	15	6
Total R&D spending	**3600**	**3056.9**	**2729.0**	**2511.9**	**2287.9**	**2032.6**	**2038.2**	**1838.9**	**1647.5**	**1572.1**	18	8

Note: Data for fiscal years. a C&EN estimates. b NSF estimates. c Data for 1969 and 1971 not available. **Source:** National Science Foundation

TOP 12 PH.D.-GRANTING SCHOOLS IN R&D SPENDING: MIT, Wisconsin head the list

$ Millions, fiscal 1978	Physical sciences	Chemistry[a]	Engineering	Environmental sciences	Life sciences	Math and computer sciences	Total[b]
Massachusetts Inst. of Technology	$37.3	$6.2	$43.2	$ 7.1	$16.6	$7.7	$119.6
U of Wisconsin, Madison	11.5	5.1	8.4	11.1	56.9	3.6	107.9
U of California, San Diego	9.5	3.6	1.9	52.6	29.4	0.4	95.2
U of Minnesota	5.0	1.8	7.6	1.8	71.1	1.2	94.7
U of Washington	4.1	0.9	4.9	11.3	56.4	1.2	89.0
Stanford U	15.6[c]	3.5[c]	21.8[c]	2.6[c]	37.7[c]	6.7[c]	88.2[c]
U of Michigan	4.0	1.2	14.5	8.6	38.8	1.6	86.9
Harvard U	11.3[c]	3.9[c]	1.5[c]	4.7[c]	52.6[c]	1.1[c]	84.2[c]
Cornell U	14.6	3.4	11.0	1.5	48.7	0.8	83.4
U of Pennsylvania	5.9	1.8	4.1	0.4	49.5	2.5	76.5
Columbia U, main division	10.1	3.3	5.8	12.5	41.0	0.5	74.6
U of Illinois, Urbana	8.0	3.2	17.2	6.9	20.5	8.8	73.9

a Included in physical sciences. b Includes social sciences and other sciences not listed seperately. c Estimated. **Source:** National Science Foundation

TOP 12 UNIVERSITY R&D CENTERS:[a] Physical sciences get big share of R&D funds

$ Millions, fiscal 1978	Physical sciences	Engineering	Environmental sciences	Life sciences	Total
Lawrence Livermore Lab	$244.1	$ 27.6	$21.9	$ 4.3	**$303.5**
Los Alamos Scientific Lab	90.9	164.5	9.2	5.7	**287.9**
Jet Propulsion Lab	50.7	128.0	8.6	4.2	**278.5**
Argonne National Lab	76.4	93.5	38.8	13.3	**231.1**
Brookhaven National Lab	64.9	19.6	7.5	13.8	**112.2**
Lincoln Lab	20.0	73.3	0	0	**103.6**
Lawrence Berkeley Lab	57.1	11.6	12.4	14.4	**99.5**
Plasma Physics Lab	76.2	0	0	0	**76.2**
Stanford Linear Accelerator Center	74.6	0	0	0	**74.6**
Fermi National Accelerator Lab	60.2	0	0	0	**60.2**
National Center for Atmospheric Research	4.9	0	28.7	0	**33.6**
Ames Lab	8.4	3.8	0	0	**12.2**

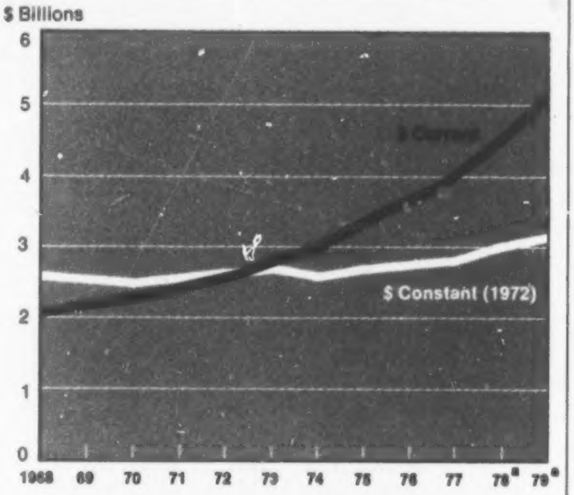
a Data for university-administered federally funded research and development centers. **Source:** National Science Foundation

UNIVERSITY SCIENTISTS AND ENGINEERS: 4% are chemists

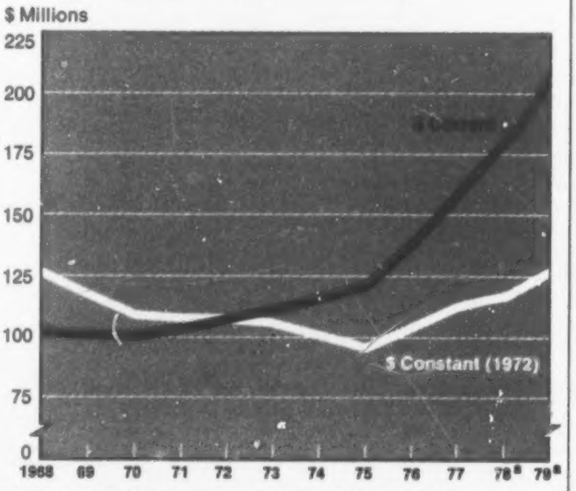
Thousands of scientists and engineers[a]	1979	1978	1977	1976	1975	1974	1973
TOTAL							
Physical scientists	**16.4**	**16.2**	**17.7**	**17.3**	**16.6**	**17.0**	**16.8**
Chemists	9.1	9.1	8.7	8.5	8.1	8.4	7.9
Physicists	7.6	7.7	7.4	7.2	7.1	7.1	7.1
Engineers	**22.7**	**21.7**	**21.2**	**20.0**	**19.5**	**19.8**	**19.4**
Chemical	1.9	1.8	1.7	1.6	1.6	1.5	1.5
Other scientists	**166.5**	**160.0**	**153.9**	**148.6**	**143.9**	**138.3**	**138.3**
TOTAL	**207.6**	**199.9**	**192.8**	**185.9**	**180.0**	**175.1**	**174.5**
FULL-TIME ONLY							
Physical scientists	**16.0**	**16.2**	**15.9**	**15.5**	**14.8**	**15.2**	**15.0**
Chemists	7.8	7.9	7.7	7.4	7.0	7.5	6.9
Physicists	6.9	7.0	6.8	6.6	6.5	6.5	6.6
Engineers	**19.1**	**18.4**	**18.0**	**17.0**	**16.6**	**17.0**	**17.1**
Chemical	1.6	1.5	1.5	1.4	1.4	1.3	1.3
Other scientists	**135.6**	**129.8**	**125.7**	**121.2**	**116.5**	**112.3**	**111.3**
TOTAL	**170.7**	**164.4**	**159.6**	**153.7**	**147.9**	**144.5**	**143.4**

Note: Data for Ph.D.-granting institutions only. a In January of each year. **Source:** National Science Foundation

Since mid-1970's, spending for academic R&D has been rising in constant dollars . . .

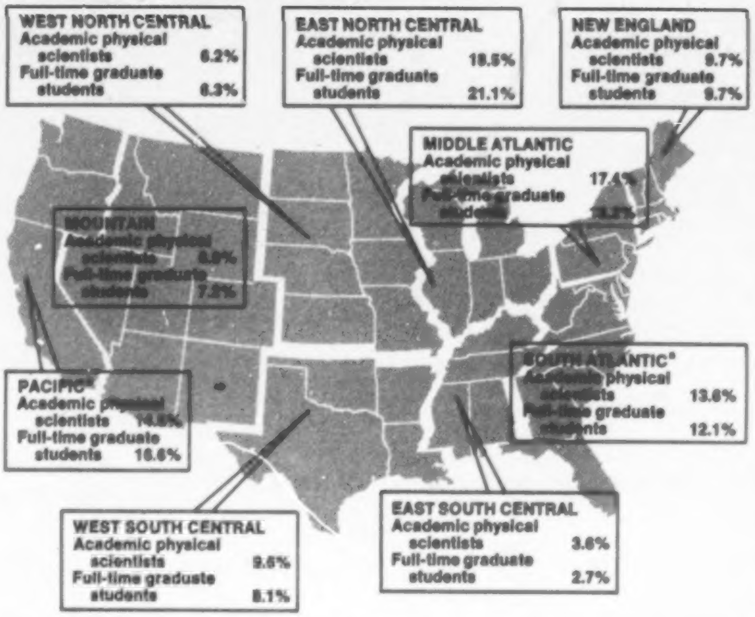


. . . as has the amount of real spending devoted to research in chemistry



a Estimated. **Note:** Fiscal years. **Source:** National Science Foundation

East North Central schools lead in graduate students and employees in the physical sciences


WEST NORTH CENTRAL
Academic physical scientists 6.2%
Full-time graduate students 6.3%
EAST NORTH CENTRAL
Academic physical scientists 18.5%
Full-time graduate students 21.1%
NEW ENGLAND
Academic physical scientists 9.7%
Full-time graduate students 9.7%
MIDDLE ATLANTIC
Academic physical scientists 17.4%
Full-time graduate students 16.2%
MOUNTAIN
Academic physical scientists 6.8%
Full-time graduate students 7.2%
PACIFIC[b]
Academic physical scientists 14.8%
Full-time graduate students 16.6%
SOUTH ATLANTIC[a]
Academic physical scientists 13.6%
Full-time graduate students 12.1%
WEST SOUTH CENTRAL
Academic physical scientists 9.5%
Full-time graduate students 8.1%
EAST SOUTH CENTRAL
Academic physical scientists 3.6%
Full-time graduate students 2.7%

Key to map: Using Middle Atlantic as an example, 17.4% of all academic physical scientists work in this geographical area and 16.2% of all full-time graduate students go to school in this area. a Includes Puerto Rico. b Includes Alaska and Hawaii. **Note:** Academic physical scientists data as of January 1979 when a total of 18,400 were employed; full-time graduate student data as of 1978 when 21,700 were majoring in the physical sciences. **Source:** National Science Foundation

CHEMICAL DEGREES: Ph.D.'s are declining as others increase

Academic year	Degrees awarded in chemistry[a]			Degrees awarded in chemical engineering		
	Bachelors	Masters	Ph.D.'s	Bachelors	Masters	Ph.D.'s
1967–68	10,847	2014	1757	3211	1156	367
1968–69	11,807	2070	1941	3557	1136	409
1969–70	11,617	2146	2208	3720	1045	438
1970–71	11,183	2284	2160	3615	1100	406
1971–72	10,721	2259	1971	3663	1154	394
1972–73	10,226	2230	1882	3636	1051	397
1973–74	10,525	2138	1828	3454	1045	400
1974–75	10,649	2006	1824	3142	990	346
1975–76	11,107	1796	1623	3203	1031	308
1976–77	11,322	1775	1571	3581	1086	291
1977–78	11,474	1692	1525	4615	1237	259

a Does not include biochemistry and geochemistry. **Source:** Department of Education's National Center for Education Statistics

GRADUATE STUDENTS: Chemistry students increase moderately

Thousands	1978	1977	1976	1975	1974
TOTAL					
Physical sciences	**25.0**	**25.3**	**25.3**	**24.8**	**24.7**
Chemistry	14.8	14.7	14.5	14.1	13.8
Physics	9.5	9.8	9.9	9.9	10.2
Engineering	**66.2**	**66.7**	**64.6**	**65.1**	**57.1**
Chemical	5.4	5.3	5.2	5.0	4.7
Metallurgical and materials	2.5	2.5	2.4	2.4	2.3
Petroleum	0.5	0.4	0.4	0.3	0.3
Biological sciences	**42.8**	**43.1**	**41.7**	**41.1**	**38.1**
Biochemistry	3.9	3.8	3.7	3.7	3.7
Other sciences	**178.0**	**174.9**	**169.0**	**165.4**	**147.4**
TOTAL	**312.0**	**310.0**	**300.6**	**296.4**	**267.3**
FULL-TIME ONLY					
Physical sciences	**21.7**	**21.9**	**21.8**	**21.4**	**21.4**
Chemistry	12.6	12.6	12.4	12.0	11.7
Physics	8.4	8.8	8.8	8.8	9.0
Engineering	**37.1**	**36.8**	**36.4**	**37.1**	**33.7**
Chemical	4.1	4.0	3.7	3.6	3.3
Metallurgical and materials	2.0	2.0	1.9	1.8	1.7
Petroleum	0.4	0.3	0.4	0.3	0.3
Biological sciences	**35.6**	**35.8**	**35.2**	**34.7**	**32.4**
Biochemistry	3.6	3.5	3.4	3.4	3.4
Other sciences	**123.2**	**123.9**	**121.5**	**118.4**	**108.4**
TOTAL	**217.6**	**218.4**	**214.9**	**211.6**	**195.9**

Note: Data for Ph.D.-granting institutions only. **Source:** National Science Foundation

SCHOOLS SPENDING MOST ON R&D IN CHEMISTRY: Top 10 account for nearly a fourth

	$ Thousands	Total spending				Federally financed spending			
		1978	1977	1976	1975	1978	1977	1976	1975
1	Massachusetts Inst. of Technology	$ 6,242	$ 4,735	$ 4,298	$ 3,740	$ 5,837	$ 4,351	$ 3,887	$ 3,436
2	U of Wisconsin, Madison	5,149	5,136	4,702	5,033	2,933	2,880	2,743	2,536
3	California Inst. of Technology	4,108[a]	5,143	3,860	3,234	3,712	4,322	3,244	2,722
4	Harvard U	3,905	2,958	3,187	2,850	3,396	2,566	2,916	2,610
5	Carnegie-Mellon U	3,828	4,425	4,231	3,729	1,542	1,079	1,552	1,294
6	U of California, San Diego	3,611	3,344	3,176	2,904	3,293	3,064	2,922	2,671
7	Stanford U	3,549[a]	2,659	2,238	1,664	3,266	2,581	2,197	1,626
8	Cornell U	3,423	3,047	2,702	2,548	3,137	2,888	2,547	2,399
9	Columbia U, main division	3,321	2,975	2,562	2,285	2,854	2,747	2,186	1,993
10	Texas A&M U	3,261	3,894	4,132	2,153	2,243	2,205	2,464	1,317
	Total first 10 institutions	**40,397**	**38,316**	**35,088**	**30,140**	**32,213**	**28,683**	**26,658**	**22,604**
11	U of California, Los Angeles	3,236	2,563	2,355	2,106	3,052	2,408	2,265	1,947
12	U of Illinois, Urbana	3,211	2,438	2,068	1,960	2,426	2,045	1,832	1,722
13	U of Chicago	3,113[a]	2,789	2,473	2,596	2,803	2,684	2,348	2,362
14	U of Texas, Austin	3,057	2,361	1,954	1,866	1,931	1,286	918	758
15	U of California, Berkeley	3,046	3,090	2,948	2,674	2,758	2,742	2,629	2,504
16	Purdue U, all campuses	2,857	2,545	2,171	1,818	2,500	2,170	1,883	1,578
17	Georgia Inst. of Technology	2,784	2,013	1,590	990	1,551	1,075	803	531
18	U of Utah	2,754	7,149	1,868	1,394	1,909	5,636	1,633	1,283
19	Wayne State U	2,740	1,280	1,028	892	1,926	1,172	950	861
20	U of Notre Dame	2,475	2,560	1,992	1,597	2,389	2,461	1,873	1,531
	Total first 20 institutions	**69,670**	**67,104**	**55,535**	**48,033**	**55,458**	**52,362**	**43,792**	**37,681**
21	Indiana U, Bloomington	2,199	1,601	1,535	1,403	1,953	1,481	1,357	1,240
22	U of Rochester	2,100	1,987	1,537	1,292	1,695	1,519	1,221	964
23	U of Massachusetts, Amherst	2,038	1,922	1,619	1,162	1,633	1,308	1,131	846
24	U of Maryland, College Park	1,975	1,389	1,568	1,540	1,690	959	1,125	1,243
25	Pennsylvania State U	1,904	1,452	1,324	1,155	1,590	1,309	1,150	967
26	Northwestern U	1,854	1,250	1,231	1,287	1,681	1,068	1,043	1,128
27	U of Minnesota	1,803	1,667	1,443	1,256	1,415	1,279	1,288	1,067
28	U of Arkansas	1,765	249	239	265	295	217	198	235
29	U of Pennsylvania	1,761	973	1,037	870	1,356	762	785	614
30	Ohio State U	1,740	2,015	1,687	1,599	1,493	1,738	1,610	1,377
	Total first 30 institutions	**88,809**	**81,609**	**68,755**	**59,862**	**70,259**	**64,002**	**54,700**	**47,362**
31	U of Pittsburgh	1,709	1,542	1,129	1,120	1,201	1,328	1,037	1,017
32	U of Southern California	1,676	764	719	727	1,381	722	664	662
33	Princeton U	1,660	1,508	1,628	1,494	1,271	1,113	1,068	1,050
34	SUNY, Stony Brook	1,637	1,201	1,009	73	1,281	1,050	907	73
35	Florida State U	1,490	1,470	1,475	884	777	727[a]	788[a]	587
36	Yale U	1,444	1,532	1,346	1,653	1,379	1,455	1,329	1,558
37	U of California, Irvine	1,435	1,376	1,119	856	1,372	1,297	1,062	814
38	Iowa State U of Sci. & Tech.	1,434	736	640	557	589	269	184	176
39	U of North Carolina, Chapel Hill	1,413	1,471	1,422	1,206	1,398	1,448	1,386	1,146
40	Colorado State U	1,398	1,100	881	667	1,193	853	766	568
	Total first 40 institutions	**104,105**	**94,309**	**80,123**	**69,099**	**82,101**	**74,264**	**63,891**	**55,013**
41	U of Arizona	1,390	1,512	1,361	1,339	881	1,145	1,017	1,087
42	SUNY College of Env. Sci. & Forestry	1,364	832	802	758	524	601	481	381
43	U of Florida	1,265	769	631	569	1,077	686	575	522
44	U of Georgia	1,265	1,311	1,443	694	642	711	825	586
45	Michigan State U	1,262	1,266	1,221	952[a]	878	1,063	842	878
46	Louisiana State U system	1,204	927	825	753	635	661	555	514
47	Case Western Reserve U	1,190	1,199	1,250	1,249	940	973	979	1,040
48	U of Houston	1,171	1,025	1,353	574	607	537	709	291
49	U of Michigan	1,171	851	1,247	826	982	604	841	635
50	Johns Hopkins U	1,160	1,160	1,107	1,092	1,084	1,102	1,048	1,001
	TOTAL FIRST 50 INSTITUTIONS	**$116,547**	**$105,161**	**$91,363**	**$77,905**	**$90,351**	**$82,347**	**$71,763**	**$61,948**
	NATIONAL TOTAL	**$174,775**	**$156,707**	**$133,715**	**$115,063**	**$133,113**	**$120,561**	**$103,186**	**$88,690**

Note: Data for fiscal years at Ph.D.-granting institutions only. a Estimate. **Source:** National Science Foundation

SCHOOLS WITH MOST SCIENTIFIC EMPLOYEES: Physical scientists declined in 1979

		Physical scientists				All scientists and engineers			
		Total		Total full-time equivalent		Total		Total full-time equivalent	
		1979	1978	1979	1978	1979	1978	1979	1978
1	**Massachusetts Inst. of Technology**	476	510	452	491	2,449	2,425	2,247	2,237
2	**U of Texas, Austin**	398	433	391	424	1,933	1,874	1,792	1,774
3	**U of California, Los Angeles**	364	347	240	331[a]	2,451	2,413	1,920	2,182[a]
4	**U of California, Berkeley**	349	318	261	302[a]	1,967	1,909	1,620	1,770[a]
5	**U of Illinois, Urbana**	293	295	147	277	2,232	2,310	1,088	2,163
6	**U of Maryland, College Park**	293	294	268	279	1,508	1,447	1,335	1,322
7	**U of Wisconsin, Madison**	289	278	277	264	3,758	3,691	3,497	3,334
8	**Harvard U**	268	252	260	243	5,414	5,135	4,779	4,261
9	**U of Michigan**	262	286	251	269	3,535	3,405	3,080	3,009
10	**U of Arizona**	235	257	228	248	1,553	1,661	1,463	1,569
	Total first 10 institutions[b]	**3,227**	**3,270**	**2,775**	**3,128**	**26,800**	**26,350**	**22,821**	**23,621**
11	**Cornell U**	227	218	203	213	2,703	2,723	2,577[a]	2,643
12	**U of Houston**	224	103	192[a]	99	892	524	803[a]	472
13	**Stanford U**	216	193	200	179	1,973	1,845	1,795	1,723
14	**Purdue U, all campuses**	215	216	205	203	1,993	1,797	1.832	1,690
15	**U of Colorado**	211[a]	209	209[a]	208	1,340	1,330	1,291	1,281
16	**U of Chicago**	207[a]	207	201[a]	201	1,357	1,357	1,329	1,329
17	**Ohio State U**	199	181	188	171	3,541	3,512	2,981	2,984
18	**Rutgers U**	195	170	187	162[a]	1,628	1,554	1,532	1,452[a]
19	**Pennsylvania State U**	193	218	186	206	2,200	2,116	2,100	1,965
20	**U of Rochester**	191	192	178	181	1,093	1,063	1,044	1,021
	Total first 20 institutions[b]	**5,305**	**5,177**	**4,724**	**4,951**	**45,520**	**44,173**	**40,105**	**40,201**
21	**Michigan State U**	183	182	180	179	1,763	1,748	1,687	1,674
22	**U of Pittsburgh**	182	153[a]	173	146[a]	1,918	1,904[a]	1,749	1,708[a]
23	**U of Minnesota**	174	179	165	169	3,581	3,471	3,034	3,146
24	**U of California, San Diego**	173	178	163	170[a]	1,057	1,069	1,005	993[a]
25	**U of Utah**	159	154	145	140	1,678	1,639	1,486	1,426
26	**Yale U**	158	131	148	127	2,060	1,911	1,895	1,755[a]
27	**Princeton U**	151	167	149	162	596	670	577	630
28	**Columbia U, main division**	150	164	150[a]	157	2,075	2,028	1,761[a]	1,721
29	**SUNY, Stony Brook**	149	134	142	131	858	764	781	715
30	**U of Washington**	148	139	141	132	2,545	2,586	2,292	2,333
	Total first 30 institutions[b]	**6,932**	**6,758**	**6,280**	**6,464**	**63,651**	**61,963**	**56,372**	**56,302**
31	**Carnegie-Mellon U**	139	133	135	126[a]	574	569	536	528[a]
32	**Louisiana State U system**	137	100	135	99	3,011	2,535	2,558	2,102
33	**U of Southern California**	128	155	121	147[a]	1,802	1,910	1,578	1,624[a]
34	**Georgia Inst. of Technology**	126	175	117	168	868	1,089	816	1,024
35	**U of Tennessee, Knoxville**	124	122	109	106	937	843	855	757
36	**U of Kansas**	122[a]	105[a]	115[a]	101[a]	1,442	1,415[a]	1,323	1,295[a]
37	**U of Delaware**	120	98[a]	108	95[a]	559	525[a]	531	504[a]
38	**U of Massachusetts, Amherst**	120	118	123	118	857	848	832	823
39	**Indiana U, Bloomington**	111	112	108	107	486	474	446	442
40	**SUNY Buffalo**	110	101[a]	107	101[a]	783	1,200[a]	699	1,093[a]
	Total first 40 institutions[b]	**8,169**	**7,977**	**7,458**	**7,634**	**74,970**	**73,371**	**66,546**	**66,494**
41	**Northwestern U**	109	122	107	122	843	968	775	902
42	**Duke U**	106	103	81	83	2,067	1,825	1,705	1,442
43	**U of Notre Dame**	105	98	103	94	348	346	338	333
44	**Oregon State U**	100	102	92	99	1,139	1,148	1,072	1,113
45	**New York U**	100	102	68	91	2,007	1,969	1,520	1,511
46	**Texas A&M U**	99	97	99	97	2,138	2,072	2,138	2,072
47	**U of Kentucky, all campuses**	98	124	91	118	1,782	1,394	1,648	1,285
48	**Johns Hopkins U**	95	85	94	83	1,874	2,319	1,755	2,086
49	**U of Iowa**	94	70	92	70	1,741	1,477	1,622	1,398
50	**Florida State U**	93	92	92	91	532	500	507	480
	TOTAL FIRST 50 INSTITUTIONS[b]	**9,168**	**8,972**	**8,377**	**8,582**	**89,441**	**87,389**	**79,626**	**79,116**
	NATIONAL TOTAL	**18,364**	**18,238**	**16,922**	**17,398**	**207,635**	**199,920**	**184,253**	**180,726**

Note: Data as of January of each year for Ph.D.-granting institutions only. a Estimate. b Ranked according to total physical scientists in 1979. **Source:** National Science Foundation

SCHOOLS WITH THE MOST GRADUATE STUDENTS: State universities rank high

		Physical science graduate students			All graduate students		
		Total	Full-time	Part-time	Total	Full-time	Part-time
1	U of California, Berkeley	639	627	12	5,542	5,322	220
2	U of Illinois, Urbana	584	581	3	4,130	3,893	237
3	U of Maryland, College Park	460	279	181	2,886	1,353	1,533
4	Massachusetts Inst. of Technology	459	459	0	3,664	3,664	0
5	U of Texas, Austin	456	445	11	3,596	3,008	588
6	U of Wisconsin, Madison	423	423	0	5,130	4,514	616
7	U of California, Los Angeles	418	411	7	4,037	3,891	146
8	Purdue U	411	378	33	3,582	2,982	600
9	U of California, San Diego	371	350	21	1,127	1,067	60
10	U of Arizona	365	344	21	2,890	2,244	646
	Total first 10 institutions[a]	4,586	4,297	289	36,584	31,938	4,646
11	Ohio State University	354	349	5	4,622	3,739	883
12	Cornell U	348	348	0	2,669	2,655	14
13	Rutgers U	319	162	157	4,249	1,721	2,528
14	Stanford U	318	317	1	3,318	3,071	247
15	California Inst. of Technology	297	297	0	856	847	9
16	Harvard U	296	296	0	2,308	2,198	110
17	Michigan State U	273	260	13	3,339	2,904	435
18	Texas A&M U	272	236	36	3,063	2,442	621
19	Iowa State U of Sci. & Tech.	269	253	16	2,299	1,731	568
20	Pennsylvania State U	268	249	19	3,256	2,349	907
	Total first 20 institutions[a]	7,600	7,064	536	66,563	55,595	10,968
21	U of Washington	265	232	33	4,370	3,378	992
22	Indiana U, Bloomington	263	262	1	1,824	1,486	338
23	Columbia U, main division	255	255	0	2,689	2,086	603
24	U of Colorado	253	248	5	3,311	2,482	829
25	U of Chicago	252	251	1	1,493	1,415	78
26	U of Minnesota	249	243	6	4,863	4,099	764
27	U of Michigan	233	216	17	4,608	4,078	530
28	U of Pittsburgh	227	205	22	2,936	1,572	1,364
29	SUNY, Stony Brook	225	208	17	2,128	1,475	653
30	George Washington U	221	47	174	2,923	702	2,221
	Total first 30 institutions[a]	10,043	9,231	812	97,708	78,368	19,340
31	U of Pennsylvania	208	196	12	2,067	1,624	443
32	U of Rochester	208	196	12	905	780	125
33	Northeastern U	208	100	108	3,050	672	2,378
34	Princeton U	206	206	0	1,006	1,006	0
35	U of North Carolina, Chapel Hill	196	193	3	2,359	2,138	221
36	U of Massachusetts, Amherst	196	171	25	1,912	1,669	243
37	New York U	195	137	58	4,239	1,630	2,609
38	Yale U	193	193	0	1,522	1,495	27
39	CUNY Graduate School & U Center	189	188	1	1,607	1,536	71
40	U of Akron	189	115	74	895	417	478
	Total first 40 institutions[a]	12,031	10,926	1105	117,270	91,335	25,935
41	U of Florida	182	173	9	2,215	1,963	252
42	U of Cincinnati	174	162	12	2,263	1,369	894
43	Northwestern U	173	166	7	1,321	1,144	177
44	SUNY, Buffalo	171	161	10	1,994	1,386	608
45	U of California, Santa Barbara	167	167	0	1,039	1,002	37
46	U of Utah	163	151	12	1,886	1,468	418
47	Wayne State U	159	126	33	2,086	1,313	773
48	Polytechnic Inst. of New York	152	53	99	2,198	354	1,844
49	U of Virginia	151	135	16	1,391	1,158	233
50	U of Oregon	150	146	4	787	702	85
	TOTAL FIRST 50 INSTITUTIONS[a]	13,673	12,366	1307	134,450	103,194	31,256
	NATIONAL TOTAL	25,037	21,651	3386	311,982	217,588	94,394

Note: Data for 1978 for Ph.D.-granting institutions only. [a] Ranked according to total physical science graduate students. **Source:** National Science Foundation

Chemical & Engineering NEWS

San Francisco meeting still slated despite hotel strike Page 7

Industrial gases

Recession has deflating effect

A Key Chemicals Review Page 11

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August 4, 1980
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Chemical & Engineering NEWS

Cover: Union Carbide's recently expanded hydrogen plant at Ashtabula, Ohio

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Recession hits industrial gas markets

Demand for oxygen, nitrogen, and carbon dioxide is down, but take-or-pay contracts are maintaining profits; hydrogen continues to hold its own

Industrial gases are going through another of their cyclical downturns. Monthly volumes are way off for most of the gases, although as yet profits are holding up, according to producers, largely because of take-or-pay contracts.

"May was the watershed for gases," according to one producer. In May, he says, customers slowed their buying of merchant gases considerably. In its fiscal third-quarter report, Edward Donley, chairman of Air Products, the second largest U.S. industrial gas producer, says, "We continue to experience margin pressure in our industrial gas business in the U.S."

Actually, the problem did not start in May but rather began last fall with a downturn in steel production. Oxygen demand, which is tied closely to steel production, immediately felt the pinch. Total oxygen output was off 4.8% in second-half 1979 to almost 214 billion cu ft from the same period in 1978.

Producers say that the recession now has spread to two of the other gases—carbon dioxide and nitrogen. Carbon dioxide has indeed shown signs of slowing in official statistics. However, there are as yet no signs of a downturn in nitrogen output in figures published by the government. There is no sign of recession in hydrogen.

The question among producers is how long the effects of the downturn will be felt. For nitrogen and carbon dioxide, there is hope that things will get back on track later this year, but oxygen is another story. After the 1974–75 recession, it took until 1977 for oxygen output to reach 1974 volumes. This year, unlike 1974–75, merchant demand is also down.

During that recession, hydrogen was the only other gas to experience a drop in output, but it had more than recovered by 1976.

The downturn in gases has brought little reduction in planned capacity expansion. There have been a few deferrals and cancellations of air separation plants, but producers say that they still expect to see a 40% increase in oxygen and nitrogen capacity by the end of 1982. All new hydrogen projects are going ahead as are carbon dioxide investment plans.

This big expansion in oxygen capacity will be nothing compared to what will come later in the decade if the synthetic fuels industry takes hold. Industry estimates point to so much new oxygen capacity, mainly on-site, to supply the synthetic fuels industry that there will be a shortage of engineers to do the job.

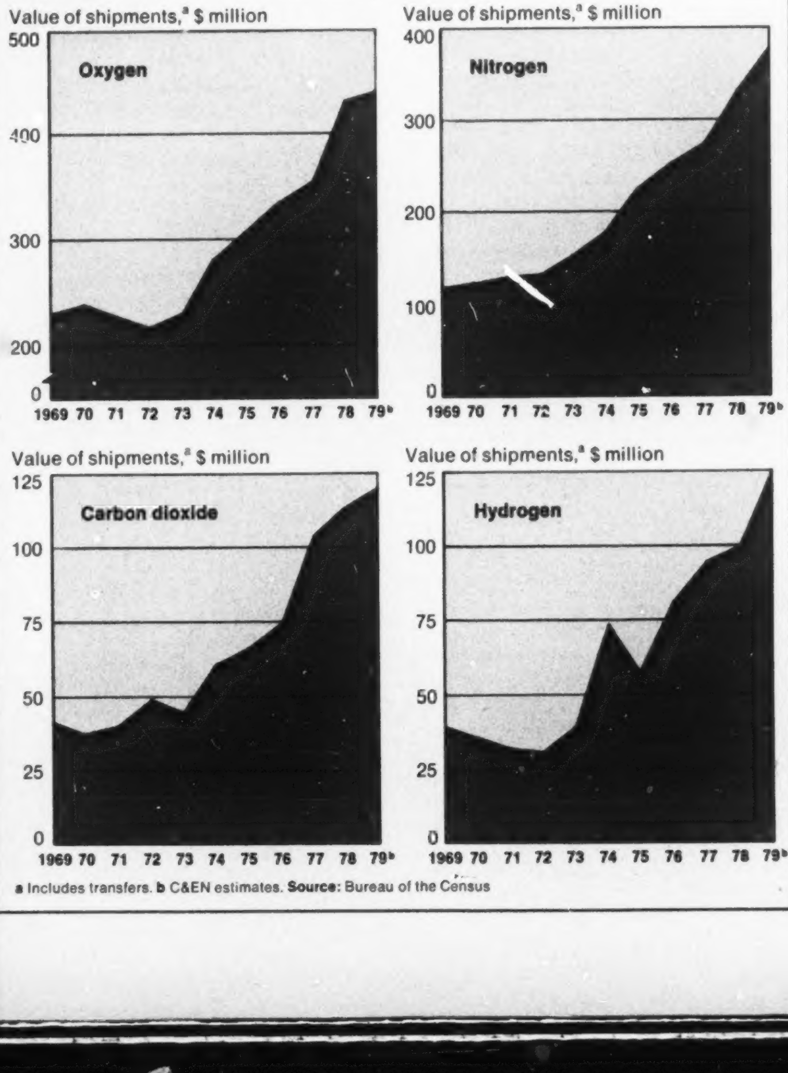
However, it will not be before 1985 or perhaps even later that this part of the industrial gas business begins even to sputter.

Also, argon, that small-volume by-product gas that once was thrown away, is still performing admirably. Because of lower use rates in air separation plants, argon production is off about 6% this year to 3.1 billion cu ft through May. However, producers say that they are still sold out. The price of argon increased another 5% in July to $2.00 per 100 cu ft. This was after an 8.6% increase the first of the year.

For a more detailed look at the 12-month outlook for oxygen, nitrogen, carbon dioxide, and hydrogen, see the following pages.

William Storck, New York

Combined value of industrial gases tops $1 billion



a Includes transfers. b C&EN estimates. **Source:** Bureau of the Census

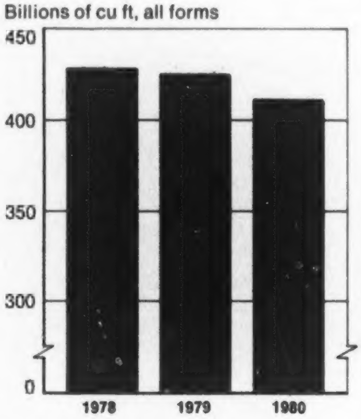
Key Chemicals

O_2

Oxygen

- ***Demand down***
- ***Costs rising***
- ***Profits compressed***

PRODUCTION



HOW MADE

Separated from air at low temperatures

MAJOR USES (merchant)

Primary metal manufacturing 30%, health services 13%, metal fabricating 6%

FOREIGN TRADE

Negligible

PRICES

37.5 cents per 100 cu ft plus shipping and equipment charges (merchant)

COMMERCIAL VALUE

More than $440 million for total production, 1979

Oxygen, traditionally the largest-volume U.S. industrial gas, is in danger of losing that distinction in the near future unless its fortunes turn around.

Output of oxygen dropped 1 billion cu ft, or 0.2%, in 1979 from 1978 to 427 billion cu ft. Production of nitrogen was only 14 billion cu ft behind oxygen and closing rapidly. Needless to say, the ongoing recession in the automobile and steel industries is largely to blame for oxygen's woes.

As in other chemicals, 1980 started out well for oxygen. Production for the first three months increased 8% to 113.4 billion cu ft. Then, suddenly, buying stopped. Production for April and May this year dropped 8.3% below that for the same months last year, bringing oxygen's growth for the first five months of 1980 to 1.2%.

Producers say that this gloomy situation continued in June and July. Figures are not yet available from the government for these months, but producers say that demand in the important merchant market is down about 10% from last year's levels.

An even bigger blow to oxygen's profitability has been energy costs—both in production and distribution. Air separation is a big user of electricity, and producers say that power costs have climbed as much as 30% in some parts of the country in the past year. The situation is bad enough, they say, to make them consider a more regionalized pricing system for merchant oxygen. In the past, oxygen has been priced on a national basis.

Pricing in no way has kept up with costs in the past year. While electricity rates were increasing 30%, prices were rising only a little more than 10% for merchant oxygen to 37.5 cents per 100 cu ft, on a large-volume liquid basis. And even this increase had to come in two stages—on Jan. 1 and July 1.

Even delivery of merchant oxygen is changing because of the cost pinch. It has long been a rule of thumb that delivery could be profitable only within a 200-mile radius of the air separation plant. But because of rising fuel costs for trucks, this radius is shrinking to the point where it is now closer to 150 miles. This is making it increasingly important to be the low-cost producer in a given competitive area.

Fortunately for producers, oxygen profits are well buffered by take-or-pay contracts in the tonnage or on-site side of the market. In this situation, large users of oxygen contract to take the gas produced in air separation plants on their property and have to buy it whether they use it or not. Profits are further protected in the tonnage area by escalation formulas written into these contracts that provide increased prices in the event of rising costs.

One big change that producers have been able to effect is adding merchant capability to tonnage plants. In the past, customers of on-site gas plants were very jealous of the gas produced there and were reluctant to allow any of it to be sold on the merchant market. Now gas producers are designing up to 30% merchant capacity into on-site oxygen plants. This capacity is dedicated to the merchant market and is not intended as a possible buffer against increased use by the on-site buyer. If the on-site customer wants it, it can be bought only at higher merchant prices. It will not be absorbed into the contract.

In fact, one of the problems this year is that supplemental sales of oxygen to steel producers have slacked off. In the past couple of years, such supplemental sales to steel producers, who have needed more oxygen than their on-site plants could generate, have soaked up much excess liquid oxygen capacity. This year, however, these supplemental sales have evaporated as steel production has fallen.

One trend that is emerging is the use of pressure swing adsorption units to produce oxygen by noncryogenic means. These units, which can be used for small installations, only now are starting to be used in the U.S.; they have been in use in Europe longer. Originally they were used in the U.S. for oxygen generation for wastewater treatment plants, but they are now gaining acceptance in remote locations for small-volume users. Their only drawback seems to be that they produce a relatively low grade oxygen of little more than 90% purity.

Oxygen producers seem to have pretty well given up on the remainder of 1980 for a turnaround. They are now looking toward 1981 to see their product finally get back on the growth track.

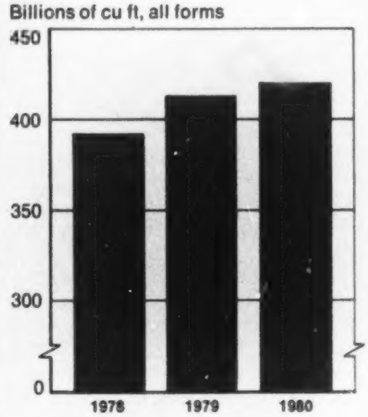
Key Chemicals

N_2

Nitrogen

- ***Growth easing***
- ***Prices up***
- ***Profits squeezed***

PRODUCTION



HOW MADE

Separated from air at low temperatures

MAJOR USES (merchant)

Blanketing atmospheres—chemical processing 14%, electronics 15%, metals 5%; freezing agent 21%; aerospace 8%

FOREIGN TRADE

Negligible

PRICES

34.5 cents per 100 cu ft plus shipping and equipment charges (merchant)

COMMERCIAL VALUE

More than $375 million total production, 1979

Last year was rather disappointing for admittedly spoiled U.S. nitrogen producers, and 1980 could be worse. Production of the second-largest-volume industrial gas in 1979 grew only 5.4% from 1978 to 413 billion cu ft. This is less than half its compound 10-year growth rate of 12%.

This year, the growth rate will slow even more, according to producers. Production in 1980 probably will be up no more than 2% from 1979, they say, to perhaps 420 billion cu ft.

Producers don't think much of the second half of 1980, evidently. For the first five months of 1980, total nitrogen production was up 17% over the comparable period of 1979. Thus, to achieve only 2% growth for the full year, production is going to have to fall off dramatically in the second half. Production growth during the first part of the year is traditionally ahead of the growth rate for the entire year, but it would be remarkable if the 17% production increase for the first five months of this year was turned into only a 2% increase at year's end.

For the moment, however, the increase in production through May has resulted in a new, possibly temporary, leader in industrial gases. Nitrogen production during that period was 193.4 billion cu ft, 6% higher than oxygen production at 181.3 billion cu ft.

The growth in nitrogen seems to be led by its oil field uses, where it is being used to maintain pressure in oil reservoirs. Previously this had been done by natural gas. Nitrogen also is being used as a carrier for other materials injected into oil wells. Producers say that nitrogen's possibilities in enhanced oil and gas recovery are just starting to be realized, although there is still some question as to how well it will work.

In many cases, nitrogen is replacing carbon dioxide in oil field use. Nitrogen producers attribute this to the relative economics of the two gases (nitrogen is cheaper, they say) and to possible corrosion problems with carbon dioxide.

This year, refrigeration use of nitrogen for food may grow as more consumers use fast-food restaurants or eat frozen foods at home. Although nitrogen has taken some of the food-freezing market away from carbon dioxide, producers indicate that there always will be a place for each. Some foods seem to have a particular compatibility with one or the other.

However, the growth in freezing and oil field uses will be somewhat offset by a slowdown in nitrogen's use as a blanketing atmosphere in metal production. This use is expected to be lower than in 1979, since the metals industry is not performing so well as it did last year. Chemical process use probably will hold about even.

The price of nitrogen is increasing but is not keeping up with costs. During the past year, the price of merchant nitrogen increased 15% to 34.5 cents per 100 cu ft from 30 cents last year. Industrial gas companies say that production costs have increased much faster than this. For the U.S., electric power rates are up 30% from last year; producers say rates have doubled in southern California in the past six months alone. The situation is bad enough, they say, to make them consider a change in traditional pricing policies.

Thus, like many products in the chemical industry, nitrogen is facing a profit squeeze. The 34.5-cent current price is for the largest users of liquid nitrogen. Charges are added for transportation and handling equipment.

The price of large tonnage or on-site nitrogen is much lower and is specified in long-term contracts containing escalation clauses for increased costs. Contracts for on-site nitrogen contain take-or-pay clauses, thus to a large extent protecting producers' profits on the gas.

This year producers broke the traditional pattern of increasing prices only once during the year. For nitrogen as well as oxygen, prices were increased on Jan. 1 and again on July 1. In the past, there was usually only one price increase—in the spring.

This switch could signal a more aggressive pricing policy in the future with tabs increasing as costs mount. Producers are also talking about regionalized pricing to make up for higher utility rates in different parts of the country. Regionalized pricing has been a standard with carbon dioxide; prices are lower in the Midwest than they are in the West and East, but the practice has not been tried, at least in recent years, for nitrogen and oxygen.

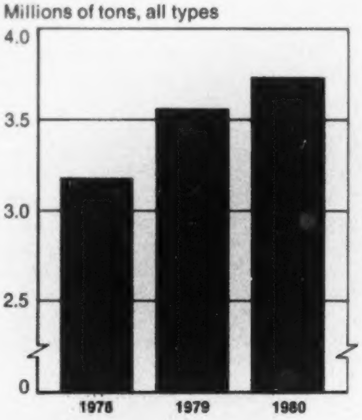
Key Chemicals

Carbon dioxide

CO_2

- ***Market still up***
- ***Feedstock pinched***
- ***Prices up slightly***

PRODUCTION



HOW MADE

Recovered from synthesis gas in ammonia production; recovered as by-product in substitute natural gas production; recovered as by-product from fermentation ethanol production; recovered from natural wells

MAJOR USES

Refrigeration—food 37%, industrial 15%; beverage carbonation 25%; other industrial uses 22%

FOREIGN TRADE

Negligible

PRICES

About $61 to $62 per ton plus equipment charge; higher on East and West Coasts

COMMERCIAL VALUE

More than $120 million for total production, 1979

Carbon dioxide finally has hit a snag, with slowed growth in both 1979 and 1980. In 1979 production grew only 5.7% for all forms, which totaled 3.53 million tons. Although many other chemical producers would be happy with such an increase, carbon dioxide producers see it as a significant slowing. In 1978 carbon dioxide production increased 12.9%. Output of this industrial gas, the third largest by volume in the U.S., grew at a compound annual rate of 11.7% between 1969 and 1979.

Because of this reduced growth rate, carbon dioxide fell from 21st to 23rd place on C&EN's list of Top 50 chemical products in 1979.

However, producers of merchant carbon dioxide were not too concerned. The merchant market still grew about 12% in 1979. Merchant carbon dioxide makes up about 20% of total U.S. production. The other 80% is used captively in large volumes such as in oil fields and for pH control, which doesn't affect the merchant market.

For first-quarter 1980, it looked as if things were going to get back on track for carbon dioxide. Total production increased 13.4% from first-quarter 1979 to nearly 767 million tons. However, in April, production fell to 254 million tons, a 1.7% decrease from April 1979. And producers are afraid that May and June were even worse.

Producers say that the merchant market is still growing, but even it is causing them to worry. Merchant sales for all of 1980 probably will be up no more than 5%—this after growing at about 15% per year for the past decade and gaining 15 to 20% in the first quarter over the same period last year.

One of the ironies of the merchant business this year is that the heat wave in the South—which one would think would help the gas in its refrigeration uses—may actually hurt merchant sales in a few months. The reason is that poultry, which is frozen with carbon dioxide, is dying before it is mature enough to be sold for food. Thus, much of it will never reach the market.

For the longer run, however, use of carbon dioxide for freezing is still growing. Producers find that during a recession, fast-food outlets become more popular. These outlets use food frozen with CO_2. Then too, the increase in the number of working women and the growing use of microwave ovens has proved to be a boon to carbon dioxide producers.

Another growing use for merchant carbon dioxide is in oil fields, up to now a captive market, where it is used for miscible polymer flooding and for treating newly drilled oil wells. This is a relatively new use for merchant carbon dioxide. In this use, however, it competes with nitrogen.

Carbon dioxide also is finally gaining acceptance for pH control of wastewater. This use has been talked about for years but has been slow starting up. Most utilities have used lime. As one carbon dioxide producer says, "The people in charge of the utilities usually won't change unless they are forced to."

Merchant carbon dioxide capacity has increased to about 16,000 tons per day, but this figure is misleading. In spite of the increase, some producers feel that there are still supply problems. The main reason is that effective production capacity depends largely on ammonia output. And since ammonia production has had its ups and downs in the past two years, effective capacity for by-product has also been sinking to where it is now—about 80% of nameplate.

This situation may not last long, however, producers hope. They are banking on being able to recover carbon dioxide from the big new fermentation process ethanol plants that will be coming on stream as part of the gasohol buildup. Carbon dioxide makers say that there will be enough of this by-product carbon dioxide to lower costs significantly and to increase profit margins.

If there is a tight supply of carbon dioxide, it has not been reflected in the price. Merchant carbon dioxide is still listed at the same price it was last year—$60 to $61 per ton plus surcharges for the Northeast and western parts of the country—but this price may not last long. A price increase of 9% is in the works.

But this increase will probably do little more than cover rising production costs. It is nowhere near the 40% price increase that producers got between 1978 and 1979. After the present recession yields to recovery, producers may try for another big hike to increase margins.

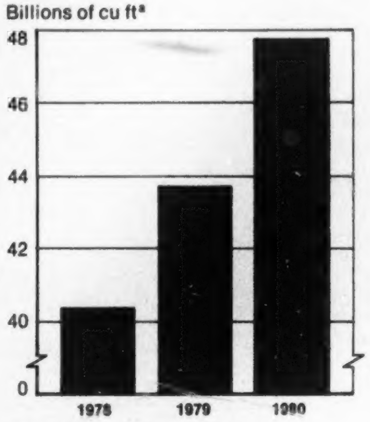
Key Chemicals

Hydrogen

H_2

- ***Demand up***
- ***Capacity expanding***
- ***Prices up***

PRODUCTION



[a] Excluding captive production.

HOW MADE

Steam reforming of natural gas

MAJOR USES

Chemical processing 63%, metallurgical uses 37%

FOREIGN TRADE

Negligible

PRICES

91 cents per 100 cu ft in 13,000-gal lots (liquid)

COMMERCIAL VALUE

More than $125 million for total merchant production, 1979

Hydrogen is the one large-volume industrial gas that producers are optimistic about this year. Output of merchant hydrogen is expected to grow more than 9% in 1980 over last year to about 47.8 billion cu ft.

Since 1971, merchant hydrogen production has grown at an average annual rate of 10.6%. So a 9 to 10% growth rate this year represents a little slowing, but not enough to cause any concern among producers.

Actually, merchant hydrogen is just a small part of total hydrogen production. Much more hydrogen is produced—mainly in the metallurgical industry—by small on-site units. Production from these units is not reported, and no one knows just how much this production is. Estimates place such production anywhere from four to 10 times total merchant hydrogen output.

These small producers of on-site hydrogen offer an opportunity for growth to merchant hydrogen producers. Much of the growth for merchant hydrogen in the metallurgical area has been in the replacement of these small on-site units.

The biggest area for growth, however, is in chemical processing for products such as plastics, pesticides, and chemical intermediates, notably aniline. In 1977 chemical processing took about 50% of merchant hydrogen production; this year it will take about 63%.

The reverse is true for hydrogen use in metal processing, where it has declined from 50% of all hydrogen production in 1977 to about 37% of production this year. In metal processing, hydrogen is mixed with nitrogen to form blanketing atmospheres. With use down in this area, producers say that they are depending to a great extent on replacement of the on-site units for market growth.

There are three kinds of merchant hydrogen—gas, liquid, and pipeline. Hydrogen gas is made by a number of companies and is shipped in small "tube trailers" holding about 150,000 cu ft.

Liquid hydrogen, which is the most profitable and fastest growing segment, is made by only three U.S. companies—Air Products, Union Carbide, and Airco. It is shipped by tank car, truck, or barge. Economies of scale make it possible to ship liquid hydrogen up to 1000 miles from the plant. By comparison, gaseous hydrogen can be shipped only about 150 to 200 miles economically.

The third kind of merchant hydrogen is that shipped by pipeline. Air Products has the only active hydrogen pipeline in the U.S. This 100-mile pipeline system (which also carries carbon monoxide) serves chemical processors along the Houston Ship Channel.

Right now there seems to be some tightness of supply of liquid hydrogen. Producers are looking forward to some capacity expansions. Present liquid capacity stands at about 128 tons per day. This includes the doubling of capacity this year at Union Carbide's Ashtabula, Ohio, plant to 17 tons per day.

There will be two more plants serving the U.S. liquid hydrogen market within the next two years. Carbide is building a 20 ton-per-day plant at Niagara Falls, N.Y., slated to come on stream in late 1981 or early 1982. And Air Products is building a 15 ton-per-day plant at Sarnia, Ont. Most of the output from this plant is slated for U.S. markets. The Sarnia plant will use hydrogen from a Dow Chemical chlorine-caustic plant at Sarnia for feedstock.

There is currently a wide range in prices for liquid hydrogen, from 91 cents to 98.5 cents per 100 cu ft in 13,000-gal lots, the industry standard. These prices are only about 9% over last year's price, hardly matching cost inflation and certainly not reflecting a tight supply. The price differences, according to some in the industry, come about because of very favorable raw materials contracts for some producers.

The price of pipeline hydrogen is about $3.00 per 1000 cu ft, delivered. This price is for the largest users; smaller users pay more. However, there are additional equipment charges and customers are, at least in part, on take-or-pay contracts. Economics of scale in production and less capital cost in the distribution network make it possible to sell pipeline hydrogen at about one third the price of liquid hydrogen.

For the remainder of the year industrial gas producers are hoping that hydrogen will help alleviate the declines in the other industrial gases. As one producer says, "As yet, hydrogen is unhindered by the recession."

Japanese chemical production turns down

The graphs on the left show that since the first part of last year, production in most segments of Japan's chemical industry has been climbing relentlessly upward.

What the graphs do not show—because the index data for the second quarter of 1980 aren't available yet—is that Japanese chemical production started turning downward around March or April. This is particularly true of petrochemicals and their derivatives. And indications are that Japanese chemical companies will face tough sledding throughout the rest of the year. As a result, their profits, which returned to some semblance of respectability last year, will probably take a beating once again.

For some companies, profit problems already are appearing. Mitsubishi Petrochemical, for instance, reports a 30% drop in pretax profits for its latest six-month reporting period that ended in June.

The problem is that while basic petrochemical producers in Japan were on last year's production binge they were chasing a demand that didn't really exist. The brisk "demand" that prompted record production of several petrochemicals was, in most cases, an inventory buildup on the part of many major customers. Well aware that raw material costs, particularly for naphtha feedstock, were constantly rising, many downstream customers began stockpiling their own petrochemical raw material requirements to beat the price increases that they knew would come.

In response to this inventory buildup, Japanese ethylene producers turned out a record 4.8 million metric tons of product last year, a 9% increase over 1978. Output of the major aromatics rose 6 to 8%. Production of the major thermoplastics soared—polyethylene up 23%, polyvinyl chloride 31%, polystyrene 19%, and polypropylene an impressive 37%.

Now, the real demand as well as the artificial demand that triggered last year's production surge is reversing itself. And with the tailoff in demand becoming painfully obvious, Japanese petrochemical producers are starting to trim production.

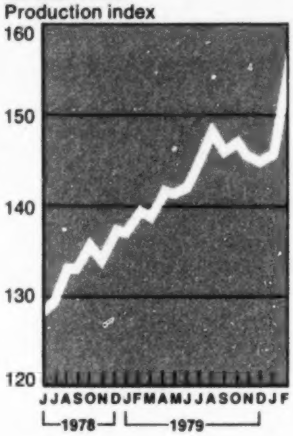
As the bellwether of the Japanese petrochemical industry, ethylene provides a good indication of what is happening there. In June, ethylene output was only 374,300 metric tons, down 4.8% from May and down 4% from May 1978. This marks the first time since April 1977 that ethylene production was lower than in the corresponding month of the preceding year.

Meanwhile, ethylene's future is even bleaker. The Ministry of International Trade & Industry estimates that ethylene production in the third quarter (July-September) will be 10% lower than the same period last year.

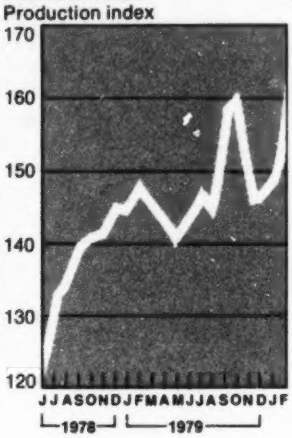
According to some Japanese petrochemical experts, the growing imbalance between supply and demand may have some serious repercussions. Petrochemical producers, usually reluctant to cut production for fear of losing a share of a highly competitive market, now realize that some adjustments have to be made. But if the necessary curtailment isn't done smoothly, the results could be disastrous.

Earl Anderson, New York

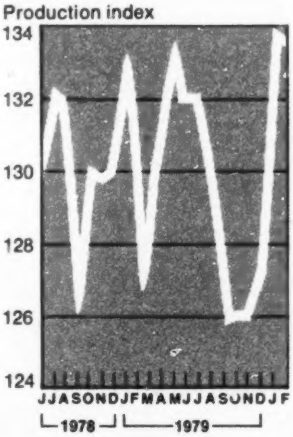
All chemicals



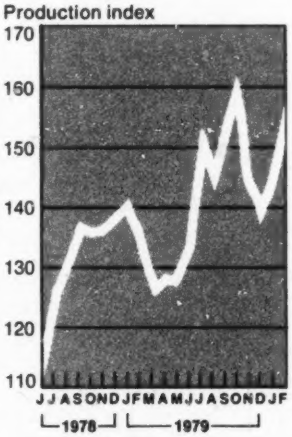
Petrochemicals



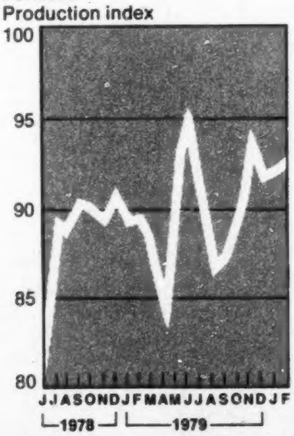
Synthetic fibers



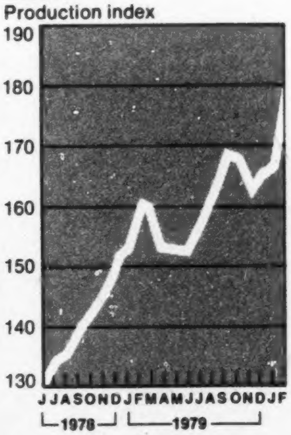
Synthetic rubber



Fertilizer



Plastics



Note: Base year for all indexes, which are seasonally adjusted, is 1975 = 100.
Source: Ministry of International Trade & Industry

Special Report

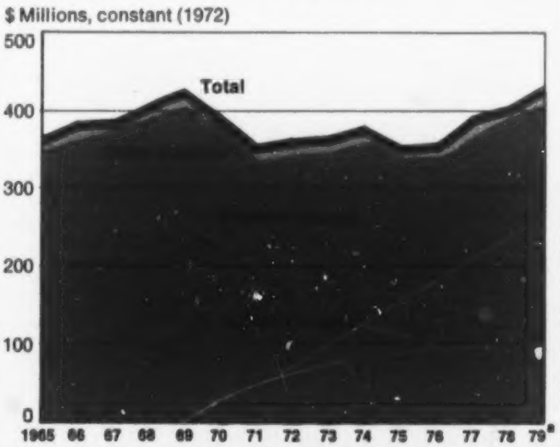
Support and manpower for basic chemical research

G. G. Meisels
University of Nebraska

Modern society is inextricably intertwined with and heavily dependent on technology. We have come to take for granted a life expectancy of 70 years or more, relatively little physical pain under normal circumstances, first-class health care, sufficient food, safe and comfortable housing, rapid and convenient transportation, and numerous other comforts and conveniences. All of these are, directly or indirectly, a consequence of the revolutionary technological developments of the past century.

It is not overdramatic to assert that the way of life we know today cannot exist without continuing technological strength. Even the arts and humanities and our ability to address social ills depend on the availability of excess resources, those that need not be devoted to sustaining acceptable living conditions; only further technological developments will provide the underpinnings for overall societal development without a reduction in the average standard of living. Our hope to improve life rather than force a reversion to life styles long past hinges on a technological approach to the solution of current problems, such as those caused by shortages of energy supplies and by pollution.

Support for basic research in chemistry has changed little in a decade



a Estimated. Source: National Science Foundation

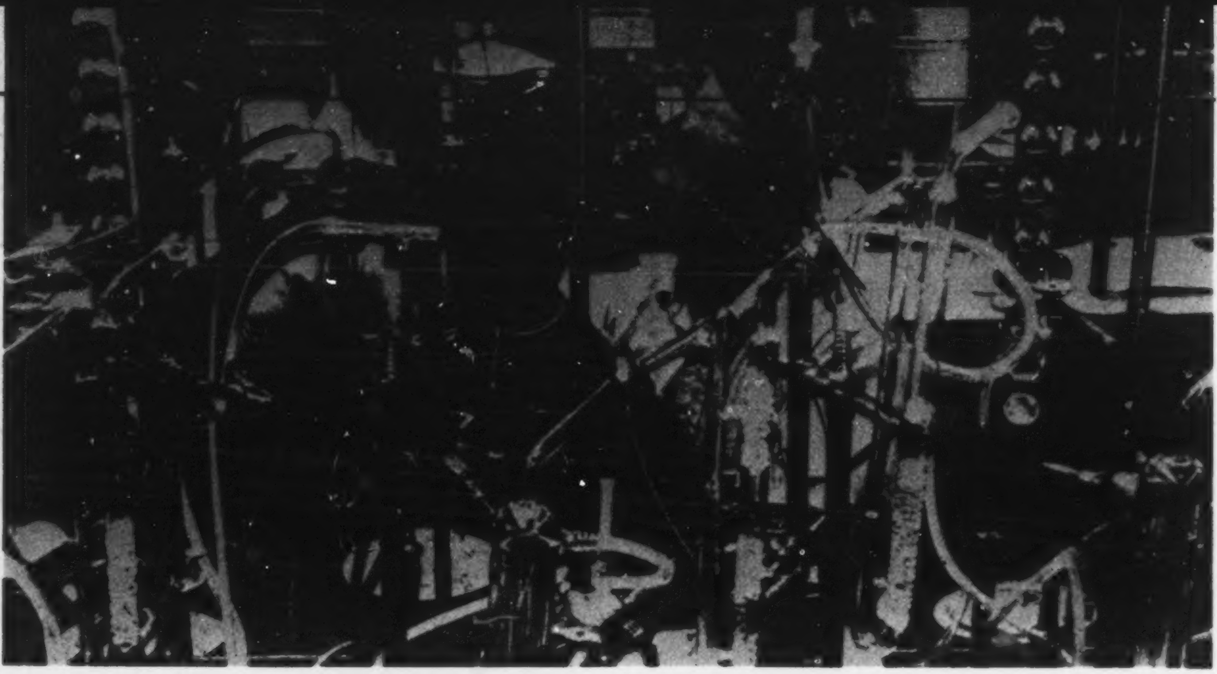
The technological revolution of the past century was firmly footed in a rapidly increasing reservoir of basic knowledge produced through basic research. No discipline is more dependent on such basic information than chemistry. During the past few years, however, increasing concern has been expressed about the reduced rate of innovation in science generally and in chemistry in particular.

This has raised several questions about basic research in chemistry. Has the pool of basic chemical knowledge expanded at a constant, increasing, or decreasing rate? How has basic research fared in comparison with applied research, and how has research in chemistry compared to research in other fields? Has it changed, in comparison with nonresearch expenditures? Is it possible, on the basis of current patterns, to project what the future may hold? Is this future acceptable, or should a deliberate effort be made to seek change?

Basic research may be defined as "original investigation for the advancement of scientific knowledge not having specific commercial or mission end-use objectives, although such investigations may be in fields of present or potential interest to the company or agency."

There is considerable (but unnecessary) debate on the merit of basic or fundamental research. Actually, good basic scientific research is simply an investigation of areas in which past study has not necessarily revealed potential applicability. Most arguments against basic research reflect a reluctance to look beyond immediate horizons. Basic research is an adventure into uncharted and unknown territory, with no guarantee of what may be found but always with the exciting prospect that it will lead to something really new. With a century of experience, we now can pursue case histories, trace developments, and state with confidence that basic research is essential for innovation; at least some basic research always has preceded major technological developments.

Case studies repeatedly have indicated this to be the case. For example, Monsanto's development in the



mid-1970's of a process for the synthesis of L-dopa, a drug for the treatment of Parkinson's disease, was based on results of basic research in catalytic hydrogenation performed at Imperial College, London, the University of New Hampshire, and the Université de Paris-Sud. Similarly, enzyme mapping, developed in the 1960's, was essential to the design, maximization of effectiveness, and eventual synthesis of diphenylether herbicides by Rohm & Haas. DDT, although first synthesized in 1874, was not used until the mid-20th century; similarly, 15 years of research elapsed between the discovery of the toxicity and the commercial development of organophosphorus pesticides. The crop savings resulting from these and other pesticides are estimated to fulfill the nutritional requirements of nearly 500 million people. Highly promising current developments include recombinant DNA technology and gas-phase ion clusters, studied for their relevance to solvation, which may hold the key to fusion power developments.

Perhaps one of the strongest arguments for research and development comes from research performed by economists. One study of profits, considered by many to be definitive, was published by H. G. Grabowski and D. C. Mueller in 1978 in *Bell Journal of Economics* and shows that, in research-intensive industries, returns on capital invested in R&D are well above the average for other types of investments. Simply put, investment in R&D is more profitable than that in other areas.

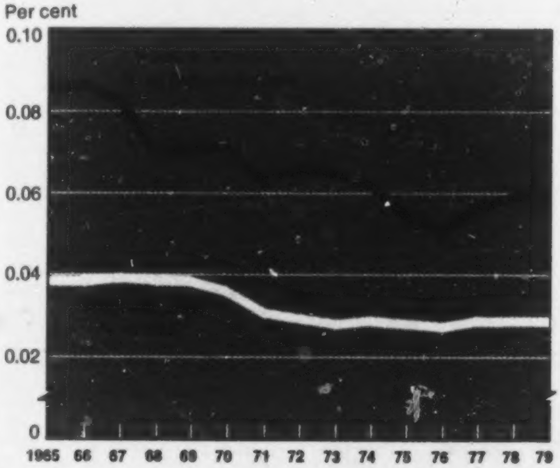
Before assessing the level of basic research effort in the U.S. over an extended time span and projecting it into the future, it is necessary to discuss what determines this level. Of course, it is not the level of effort that matters but its output. Unfortunately, changing patterns of publication, the increase in the number of scientific journals, and changes in the nature of research itself over the years all suggest that merely counting publications or patents is neither a suitable nor a reliable measure.

Research spending

Therefore, spending for basic research, in constant dollars, was chosen as the first measure of research effort. One advantage of doing so is the availability of data. These show that (in inflation-adjusted dollars) there has been no statistically significant change in the level of support for basic research in chemistry during the past 10 years. However, about 5% of total support has shifted to federal funds and away from industry since 1968. On the performance side, the proportion of total expenditures for basic chemical research at universities has not changed materially during the same period, but 6 to 8% of the total has moved away from industry and into nonuniversity laboratories supported by federal funds.

Basic research is less costly, per scientist, than R&D in general. According to National Science Foundation data for 1977, for example, industry spent $76,100 for each scientist and engineer engaged in all types of R&D. For basic research in chemistry, however, the cost was only $51,800 per scientist. In academia, basic research in chemistry is considerably less expensive, costing just $27,700 per scientist engaged. The low cost of basic research in universities probably is caused by a number of factors, such as the participation of graduate students who are not included in the manpower base used for the calculation or of postdoctoral fellows who also are still in

Chemical basic research gets a smaller share of GNP and the federal budget



Most Ph.D.[a] chemists engaged in basic research work at universities

Employer	1975 In basic research	1975 All activities	1977 In basic research	1977 All activities	1977 % of total work force
Universities and four-year colleges	2990	13,320	3796	13,698	33.7%
Industry	1976	18,278	2101	18,664	45.9
Federal government	620	1,697	639	1,810	4.4
Nonprofit organizations	380	1,071	319	1,048	2.6
Hospitals	120	387	104	446	1.1
Two-year colleges and secondary schools	—	1,082	—	1,094	2.7
Other employers	72	389	49	554	1.4
Unemployed or retired	—	2,560	—	3,336	8.2
TOTAL	6158	38,784	7008	40,650	100.0%

a Full-time equivalent. **Source:** National Science Foundation

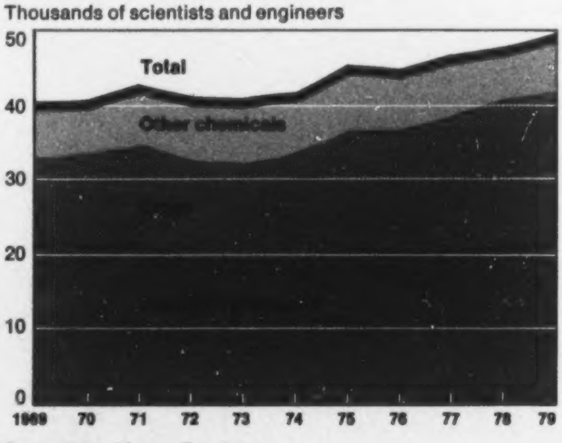
the educational process, as well as unaccounted contributions of faculty release time.

It is reasonably clear that in the past the total performance of basic research has been limited by the funds available. It is not at all obvious, however, that this budget-limited model will be correct in the future. As demand for scientists to work in energy and other areas increases and production of Ph.D.'s, who direct basic research, decreases, the availability of qualified personnel rather than money may limit creative effort in chemistry in a few years. Then forecasts of future effort would require a manpower-limited model.

Manpower indicator

A second measure of research effort may be based on the assumption that the number of individuals engaged in basic research rather than the number of dollars spent on it is what determines the level of that creative endeavor. This approach implies, of course, that there is no change in the inherent creativity or ability of those who perform basic research—that is, that the quality and composition of the research work force has not changed.

Scientists doing R&D in the chemical industry have increased moderately



Source: National Science Foundation

Unfortunately, information on manpower is not nearly so extensive as that on spending. NSF initiated a biennial study in 1973 on the characteristics of doctoral scientists and engineers, but the data are reliable for only 1975 and 1977. (In the 1973 report, the number of Ph.D.'s found to be engaged in academic basic research is lower than the total number of postdoctoral fellows.) The annual salary survey of ACS members also provides relevant data, which compare well with those from NSF.

NSF data show that the full-time equivalent of 3796 Ph.D. chemists were engaged in basic research at universities and four-year colleges in 1977. Assuming that the approximately 2600 postdoctoral fellows in Ph.D.-granting universities that year were engaged full time in basic research and that the contributions to basic research from schools that do not grant a Ph.D. are small enough to be neglected, it appears that university faculty members spend about 30% of their time on research.

It is difficult to assess whether there has been a change in the manpower performing basic research in universities. Applying the 30% estimate for faculty time to data from the ACS "Directory of Graduate Research," a full-time equivalent of 3711 Ph.D.'s can be estimated as having been engaged in basic chemical research during the 1972–73 academic year, indicating a net increase of less than 1% a year between 1973 and 1977. (Data from the ACS directory should be quite accurate because all individuals in Ph.D.-granting universities are sampled through their departments.)

The apparent increase of 7% per year between 1975 and 1977 in Ph.D.'s doing basic chemical research at universities indicated by the NSF data may result from the inclusion of permanent staff people who are not faculty members. Because there was no similar increase in financial support for academic research, it well may be that the overall level of research effort remained constant while performance shifted from graduate students, whose enrollment has declined, to support staff, which ACS data indicate increased nearly 19% a year from 1973 to 1977. The increase cannot be ascribed to postdoctoral fellows; their numbers did not vary appreciably between 1973 and 1977. Recent evidence from ACS surveys strongly indicates, moreover, that the number of postdoctoral fellows has declined substantially since then.

The number of scientists and engineers engaged in basic research in industry can be estimated from the total number of individuals in industrial R&D, the fraction of industry R&D budgets devoted to basic research, and costs per scientist. Such an estimate indicates that in the 10 years through 1978, the number of chemists in basic research in industry has declined about 2% per year.

An estimated 40% of all R&D in industry is performed by Ph.D. chemists. The degrees held by individuals engaged in basic research in industry can be ascertained only indirectly; the most extensive survey, made of ACS members, includes a larger fraction of Ph.D.'s than their representation among all chemists in the U.S., as measured by NSF data. The data suggest, though, that in 1976 basic research in industry was performed by 5500 chemists, of whom about 2000 had Ph.D. degrees, 1300 M.S. degrees, and 2200 B.S. degrees. These proportions are very similar to those for chemists doing R&D overall. Apparently, the type of research being done is not material to the composition, by degree, of the work force doing it.

However, in general, individual chemists with a Ph.D. degree are much more likely to be in basic research than are chemists not holding that degree, particularly since only chemists with a Ph.D. are likely to be employed by universities. NSF data indicate that about 17% of all

Cost of conducting research in the chemical industry, per scientist, has not changed greatly

$ Thousands, constant (1972), per scientist and engineer	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969
Chemicals and allied products	$48.7	$48.8	$49.7	$47.9	$48.5	$48.3	$47.1	$45.5	$46.8	$47.7
Industrial chemicals	55.7	56.5	55.8	53.1	54.7	55.4	54.0	51.2	51.2	53.0
Drugs	43.4	45.9	47.4	47.9	46.8	48.7	46.5	45.0	43.9	46.6
Other chemicals	42.1	38.3	38.0	34.0	39.0	32.1	33.4	37.0	36.6	33.6
All industry	52.3	53.7	54.0	52.3	54.6	56.0	55.3	53.2	52.6	54.8

Source: National Science Foundation

Ph.D.'s are engaged in basic research; in industry, 5.7% of B.S. chemists and 6.6% of M.S. chemists are similarly engaged.

Quality of work force

Creative effort and innovation do not depend on numbers only, of course, but also on quality. An alarming survey made last year by Douglas C. Neckers, chairman of the chemistry department of Bowling Green (Ohio) State University, of 75 universities and colleges indicates that graduate study in chemistry no longer attracts those undergraduates who are near the top of their class or highest in grade-point average (C&EN, Dec. 17, 1979, page 17). Such students enter medical school instead. In the period from 1964 to 1966, the grade-point average of chemistry majors entering medical school and those choosing graduate study in chemistry was the same. Since 1973, however, the average for medical students has exceeded the average for graduate students 0.3 point, well outside statistical error. Neckers' survey has been verified by a 1979 ACS survey, which shows that chemists with a B.S. degree who are working for a graduate degree in chemistry had a grade-point average of 3.37 whereas those who are in medical school had an average of 3.65.

Creative ability and grade-point averages are not necessarily closely related, but the average has long been used as a selection criterion because it is the only measure available. Neckers ascribes the lower average for graduate students largely to the heavy publicity given the short-term job market for chemists during the early to mid-1970's. He concludes that "students of lesser ability are being fed into the American research establishment in chemistry." If this is correct, it would signal a decline in the quality of new entrants into the chemical work force that demands strong countermeasures.

While the absolute level of basic research in chemistry, measured in terms of constant-dollar support and manpower, has been nearly constant during the past 10 years, the U.S. economy has expanded. It is important to ascertain, therefore, whether basic research has kept pace. If it has not, then basic research has decreased relative to other sectors of the economy, and with it innovation—provided that the latter is in some way proportional to the level of basic research or perhaps even only to total R&D effort.

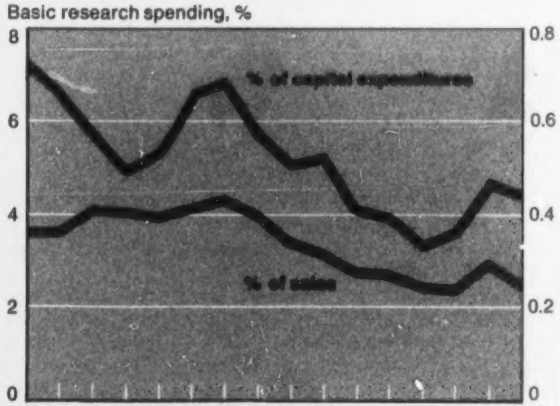
It is, of course, well known that the proportion of national resources devoted to basic research and to R&D in general has decreased substantially. The decrease of 5% a year in relative federal support of basic research in chemistry parallels a decline in support of other types of R&D. In the chemical industry, also, basic research has been de-emphasized, shrinking from 7.6% of total capital expenditures in 1963 to 4.5% in 1978, a decline of 3.5% per year, or from 0.37% of sales in 1963 to 0.25% in 1978, a decrease of 2.6% per year. Ironically, economic studies demonstrate that such a change affects profits adversely!

A conference of industrial and academic scientists sponsored last fall by Dow Chemical at Midland, Mich., brought to the surface perceptions that the reduction in innovation experienced by the chemical industry may be a result of government policies but also, perhaps, of a lesser dependency of academic research on industrial support, which has reduced the flow of information between universities and industry. But there may be a more direct cause: a marked decrease in the importance industry ascribes to basic research. This reduced emphasis probably also has contributed to weakening the academic-industry interface, although other causes for disaffection may exist, such as a lack of understanding of student actions and university and industry reaction during the turbulent Vietnam war years. Funding for university basic research from nonfederal sources, probably mostly from the states, has actually increased from 21% to 24% of the total in the past 15 years; therefore, increased federal support cannot be held responsible for weakening the academic-industry interface.

Future research levels

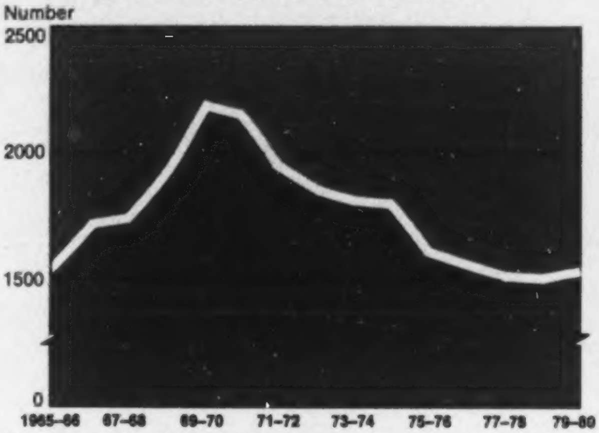
If past patterns of funding continue, there will be little if any change in the level of basic research, at least in terms of constant dollars. Increases planned in federal support are not quite at the inflation level and attempts to balance the federal budget may cause some further reduction, in constant dollars. Nor is there any indication that industrial funding for basic research is rising, although last year's Midland conference and future meetings of this kind may change the climate, and therefore the priority industry gives to basic research. There is also

Chemical companies put less emphasis on basic research



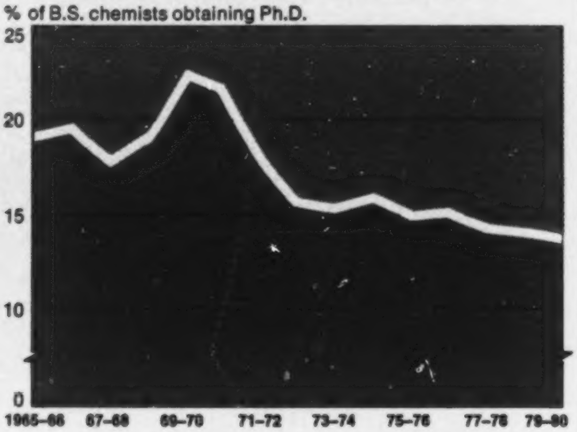
Source: McGraw-Hill Economics Department

Ph.D.'s granted in chemistry decline...



Note: Data for 1978–79 and 1979–80 are ACS estimates.
Source: National Center for Educational Statistics

...as smaller share with B.S. earn Ph.D.



Note: Data for 1978–79 and 1979–80 are ACS estimates; data represent Ph.D.'s granted in chemistry as a percentage of B.S. degrees in chemistry granted four years earlier. **Source:** National Center for Educational Statistics.

no indication that university faculties will increase at those institutions where research is a major faculty responsibility. Although there is considerable fear that student enrollment will begin to decline in the mid-1980's, this may well occur primarily at schools without a strong commitment to research. Staff reductions that eventually may take place, therefore, would not materially affect the level of basic research in universities. However, a continuing decline in chemistry majors and Ph.D. graduates nonetheless may reduce overall academic effort.

These arguments reflect a support-limited model. However, the employment for scientists and engineers generally is increasing. Technical employment in the chemical industry has increased at the rate of 1.7% per year since 1963. This is coupled with a replacement need of about 1.6% per year for Ph.D. chemists as a result of death and retirement. (The latter is a low estimate.) NSF estimates a future increase of 3.2% per year in industrial manpower in the physical sciences for a total demand of 4.8%. In addition, universities expect to increase their current manpower 5.2% this year.

Based on conservative assumptions that the number of employed Ph.D.'s increases 2.4% per year, a total demand of 4.0% for new Ph.D. chemists can be estimated, suggesting that about 1800 new Ph.D. chemists will be needed in 1981 and 1900 by 1985. Ph.D. production in the past few years has been below this level. If the number of Ph.D.'s awarded annually should continue to decline at a rate of 4.0 to 4.7% per year, as it did between 1970 and 1978, 1985 may see only about 1200 Ph.D.'s in chemistry graduating from U.S. universities. During the past three years, Ph.D. production appears to have leveled off at about 1530 annually, so the shortfall may not be so severe as this analysis would indicate. However, if indeed the guidance of basic research is primarily in the hands of Ph.D. chemists, the level of basic research may soon find itself limited by manpower, not by support funds.

These findings differ from a projection made by NSF last year which suggests that 7 to 9% of Ph.D. physical scientists will have to find employment outside their field between 1982 and 1987, compared to 7.1% in 1977. The discrepancy probably is the result of NSF's assumption that the number of doctoral scientists graduating annually will parallel the increase in R&D spending in industry, which it estimates will be 3.2% a year. Using this as-

Basic research subcommittee recommendations

Recognizing the importance of basic research, the ACS Council Committee on Economic Status, under the leadership of Samuel M. Gerber of American Cyanamid, last year appointed a subcommittee on basic research, chaired by the author, to investigate the level of such research and establish to what extent, if any, it has changed in recent years. The article on the adjacent pages is adapted from a fully documented report, available from the author (G. G. Meisels, Department of Chemistry, University of Nebraska, Lincoln, Neb. 68588), that was prepared as part of that investigation. Based on the findings of the report, the subcommittee on basic research recommends:

1. We urge those responsible for the support and direction of basic research in industry and the various branches of government, as well as state and national legislators, to provide continuity and stability for basic research and to isolate its fate as much as possible from the normal cycles of business performance, other budgetary priorities, and political pressures.

2. We ask for the dedication of additional resources to basic chemistry: that industry at least retain the balance of expenditures with respect to capital investments or sales prevalent in the early 1960's; and that the federal government at least keep the support for basic research in chemistry at the same proportional level within the total federal outlays it did in the early 1960's. (The net cost to the federal government to establish a policy such as the one recommended would be less than $60 million annually, or about 0.01% of the total federal budget.)

3. We recommend that the American Chemical Society establish an effective program to convey to high school counselors, college counselors, and college and university department chairmen in the sciences a clear and timely picture of the manpower balance anticipated for the future on the basis of current trends.

sumption, NSF projects that about 1900 Ph.D.'s will be granted in chemistry in 1982 and 2150 in 1987. This is highly improbable. This analysis indicates, on the basis of data for 1976 and 1977, that a shortage of doctoral chemists already should exist. This is supported by a number of observations. Peterson's annual guide to employment of scientists lists more than 100 companies that are seeking chemists, with doctoral chemists in analytical, physical, organic, and polymer chemistry in particular demand. The volume of classified advertising in C&EN for job openings available to chemists and engineers has been rising steadily, at least until very recently, to a level comparable with that of the mid-1960's. Last November, Betty M. Vetter of the Engineering Manpower Commission projected a substantial future demand for chemists. And the High Technology Recruitment Index compiled by consultants Deutsch, Shea & Evans of New York City, last year was at the second highest level in its 19-year history.

Academic employers also note that it has become extremely difficult to hire postdoctoral fellows; this indicates that the buffer of the postdoctoral pool established in the first part of the past decade largely has been used up. Department chairmen find that the number of applications for advertised junior faculty positions is down to a fifth or tenth of what it was about 1975. There can be little doubt that the supply of doctoral chemists is already marginal—or, more likely, insufficient.

Future demand for B.S. and M.S. chemists is much more difficult to assess because their net production is uncertain; many go on to obtain a Ph.D. degree. Moreover, the employment of B.S. chemists is not so clearly tied to chemical R&D as is that of Ph.D.'s. Demand for Ph.D.'s could be met by encouraging more top-quality B.S. chemists to pursue advanced studies. About half of B.S. chemists initially plan to attend graduate school, but only roughly a third eventually earn a Ph.D. Academic advisers at the college level therefore could play a major role in helping the profession balance supply and demand for Ph.D. chemists.

One major difficulty in projecting employment is the sensitivity of such estimates to federal policies. New legislation, such as the $1 billion energy research program once considered, can create thousands of jobs for chemists and other scientists. Similarly, plans to reduce federal expenditures by agencies with an important research support mission would eliminate a like number of jobs.

It cannot be overemphasized that research needs continuity and stability of effort and support. Chemists (or other scientists) who must leave basic research to stay employed cannot effectively return to it after a few years and may not want to do so. Basic research is strongly dependent on close communication among leading scientists and requires a grasp of a wide set of often seemingly unrelated concepts and facts, which can be developed only by intense concentration over a number of years. Once this grasp is acquired, it can be maintained with much less effort while the investigator is really able to make a contribution. But ideas and concepts change; after two or three years away from a field a scientist must begin anew, and productivity is interrupted not for two or three but for five to seven years.

Termination of research or vacillation in direction that leads to frequent changes of research areas, therefore, causes major inefficiencies. The effect of cutbacks is especially severe because the number of people engaged in basic chemical research is quite small, probably less than 10,000 in the entire U.S. Supposedly temporary cutbacks or unstable direction thus can have severe long-range effects, particularly since production of highly qualified and trained personnel is a time-consuming process with a lead time of four to seven years.

It is often argued that information derived from basic research is an international resource and that other countries successfully exploit basic research performed in the U.S. The effectiveness of basic research depends in part on the efficiency with which information is transferred in-house or from academic and other basic research laboratories to industry. New concepts are often conceived years before they appear in the literature; they are communicated orally, initially personally among interested scientists and later at scientific meetings. Cultivation of a strong academic-industry interface could give U.S. industry a competitive advantage through a shorter lead time in the exploitation of new concepts generated in the U.S.

There is some evidence that the U.S. is falling behind in scientific matters, particularly in scientific instrumentation. It is disturbing, for example, that four of the six regional facilities established by NSF in 1978 are being equipped with instrumentation designed and manufactured overseas.

Research basically is incremental or pyramidal in nature, with one discovery building upon another. To be effective, a large part of exploratory research should be in uncharted areas. Chemistry is a relatively mature science, and a number of its fields, especially those in which results can be predicted most readily and defended economically, are no longer likely to yield major new developments. They are, in a sense, like a well-worked-over mineral claim or oil field. Basic research must seek to be unconventional and extend itself into novel areas. But new areas usually will be more difficult and expensive to investigate, since it is human nature to exploit the easy areas first.

Therefore, it should be recognized that basic research is becoming more expensive. Lead times before discovery of useful new information may increase, despite the superior instrumentation now available. Most important, however, basic research requires continuity. It cannot be turned off or on at short notice and still be effective. ☐

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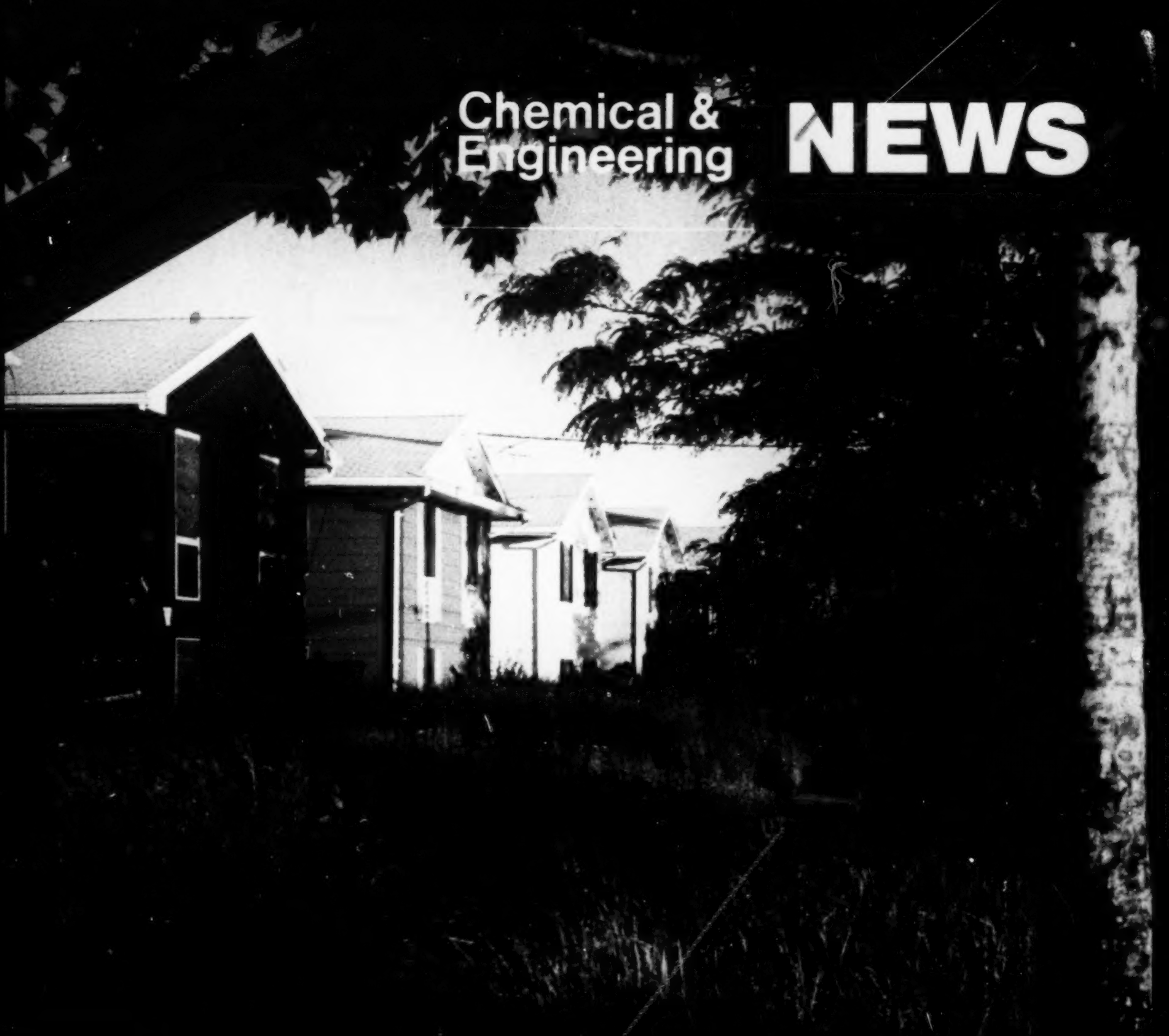
Gerhard G. Meisels has been chairman of the department of chemistry at the University of Nebraska since 1975. A native of Vienna, Austria, he received his graduate training and did postdoctoral work at Notre Dame. He joined Gulf Oil as a research chemist in 1956 and later performed research for Union Carbide before going to the University of Houston in 1965. He has been a member of the ACS Committee on Economic Status since 1977. This year he chaired a Gordon Conference on radiation chemistry and has just completed a term as chairman of the Committee on Fundamentals of the American Society for Mass Spectrometry. Meisels is the author of about 100 publications dealing with the chemistry of gaseous ions, mass spectrometry, photochemistry, ion-molecule reactions, unimolecular reactions of state-selected ions, and radiation chemistry.

Chemical & Engineering NEWS



LOVE CANAL

Testing the frontiers of science and law Page 22

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Cover: Houses in Love Canal area were among the first group to be evacuated in August 1978. Photo by C&EN's Lois R. Ember

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- ***Synthetic fuels are competitive*** *with conventional fuels if the indirect cost of using imported oil is considered.* ***Page 5***
- ***ACS staff members prepare to shift the site*** *of the fall meeting from San Francisco to Las Vegas with as few disruptions as possible to meeting-goers.* ***Page 5***
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Chemical earnings sag 12% in second quarter

Profits of major chemical companies dropped suddenly, sending profit margins for the quarter plummeting to 5.6% from last year's 7.0%

William J. Storck
and William F. Fallwell
C&EN, New York

The string of earnings increases has finally run out for the U.S. chemical industry. After six straight quarters of phenomenal gains by chemical companies, earnings growth did not just stop in the second quarter this year. It upended.

Combined earnings of the 40 largest chemical companies in C&EN's quarterly survey fell 12% to $1.3 billion in the second quarter. At the same time, combined sales increased 9% to $22.7 billion.

The drop in earnings would have been even more dramatic had it not been for smaller chemical companies propping up earnings of the larger ones. Among the 20 largest companies, earnings fell 16% to a combined $1.1 billion from the same period last year. At the same time, combined earnings of the 20 smaller companies were climbing about 22% to $219 million.

The drop in chemical earnings in the second quarter also dampened the earnings increase for the year to date. For the first half of 1980, earnings for the 40 companies gained 7%—this after a 21% increase in the first quarter.

The combined profit margin for these companies in the second quarter, 5.6%, is also quite a drop from the 7.0% profit margin achieved in the second quarter last year. The latest figure is at the lowest level since fourth-quarter 1977, when it dropped to 5.4%.

Chemical industry leaders for second-quarter 1980. . .

	Sales		Earnings		Profitability	
Rank		$ Millions		$ Millions^a		Earnings as % of sales
1	Du Pont	$3412.3	Du Pont	$176.6	Texasgulf	24.6%
2	Dow Chemical	2522.7	Dow Chemical	171.2	Freeport Minerals	20.2
3	Union Carbide	2370.9	Union Carbide	149.9	Lawter Chemicals	15.6
4	Monsanto	1548.6	W. R. Grace	86.7	International Flavors	15.4
5	W. R. Grace	1541.4	Allied Chemical	73.0	Great Lakes Chemical	14.3
6	Allied Chemical	1364.1	Texasgulf	59.1	Lubrizol	12.1
7	American Cyanamid	837.0	Diamond Shamrock	56.3	Nalco Chemical	11.7
8	Celanese	803.0	Williams Cos.	52.3	Loctite	11.6
9	Diamond Shamrock	769.1	PPG Industries	39.7	Petrolite	10.7
10	PPG Industries	753.7	International Minerals	35.9	Baker Industries	9.9

a After taxes. Note: For 40 chemical companies listed on page 10.

. . . and for first-half 1980

	Sales		Earnings		Profitability	
Rank		$ Millions		$ Millions^a		Earnings as % of sales
1	Du Pont	$6980.2	Du Pont	$421.0	Texasgulf	26.3%
2	Dow Chemical	5332.2	Dow Chemical	401.7	Freeport Minerals	21.4
3	Union Carbide	4936.5	Union Carbide	369.8	Lawter Chemicals	15.8
4	Monsanto	3371.1	Monsanto	187.4	International Flavors	15.2
5	W. R. Grace	2905.5	W. R. Grace	151.9	Great Lakes Chemical	15.1
6	Allied Chemical	2748.3	Allied Chemical	141.2	Lubrizol	12.5
7	American Cyanamid	1667.0	Texasgulf	136.7	Baker Industries	12.5
8	Celanese	1650.0	Diamond Shamrock	112.6	Loctite	12.0
9	PPG Industries	1550.0	PPG Industries	94.4	Nalco Chemical	11.4
10	Diamond Shamrock	1524.5	Stauffer Chemical	89.7	Petrolite	9.8

a After taxes. NOTE: For 40 chemical companies listed on page 10.

Chemical company executives lay the second-quarter drop in earnings squarely on the recession. For example, Irving S. Shapiro, chairman of Du Pont, says: "During the quarter the U.S. recession, which was felt initially in the automotive and housing industries, spread to almost all other U.S. markets, affecting most of our product lines."

John W. Hanley, chairman and chief executive officer of Monsanto, says, "Monsanto's second-quarter results clearly reflect the severity of the recession that we are now witnessing. While we had anticipated an economic downturn, we had not projected adequately the extent of the credit constraints imposed by the Federal Reserve and the significant impact that those credit constraints had on the demand for automobiles and housing."

Pennwalt chairman Edwin E. Tuttle notes the suddenness of the downturn. "Although the quarter started off strong, it turned soft rather abruptly," he says.

And William S. Sneath, chairman of Union Carbide, says that adverse effects on earnings were caused by "an across-the-board decline in domestic sales volume, reflecting softness in the U.S. economy. With volume dropping and raw material costs rising, and with no price relief over the prior quarter, the pressure on profit margins continued."

Executives also do not see an immediate end to the problems. James G. Affleck, chairman of American Cyanamid, says that, based on results thus far in 1980, "We now expect that earnings for the year as a whole will fall below the record level achieved in 1979. Our expectations are based on the likelihood that the U.S. recession will be deeper and longer than anticipated."

At Rohm & Haas, chairman Vincent L. Gregory Jr. says, "With the current state of the U.S. economy and continued inflationary pressure on our costs, we will find it difficult to reach last year's record earnings for the entire year." Harold E. Thayer, Mallinckrodt's chairman, says, "As

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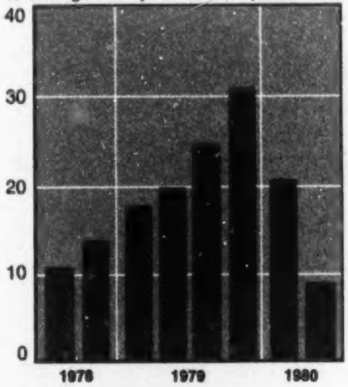
Chemical Industry Second-Quarter Results

- **Sales were up 9%**
- **But earnings dropped 12%**
- **Profit margins fell**
- **Production decreased 1.8%**
- **Prices climbed 20%**

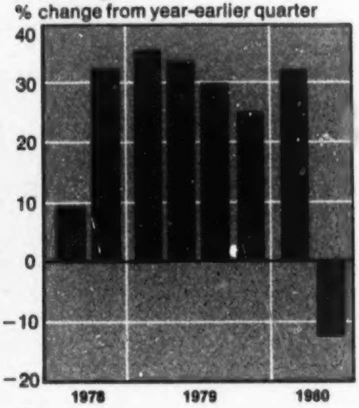
Sales

% change from year-earlier quarter



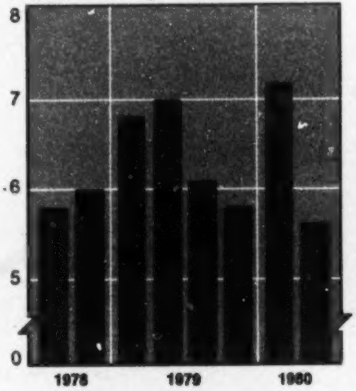
Earnings

% change from year-earlier quarter



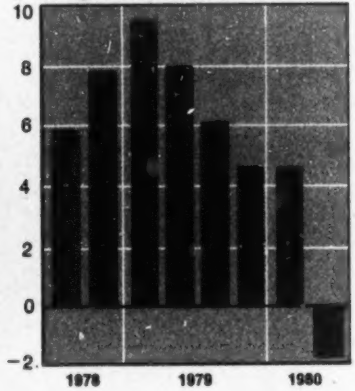
Profit margins

After-tax earnings as % of sales



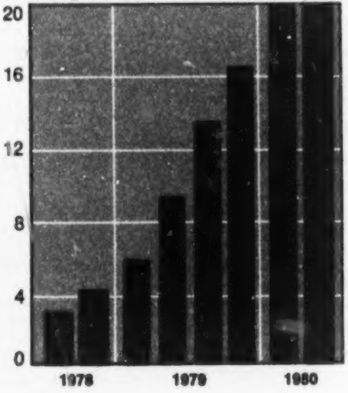
Production

% change from year-earlier quarter



Prices

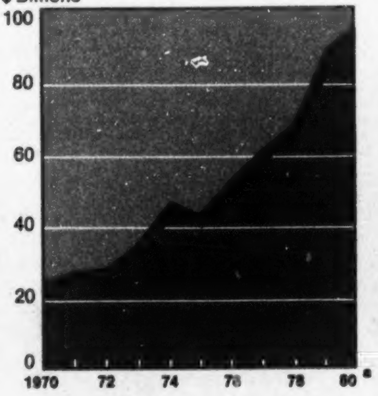
% change from year-earlier quarter



For 1980 sales likely will increase about 8% to top $94 billion; earnings will drop to $5.1 billion; profit margins will fall to 5.5%

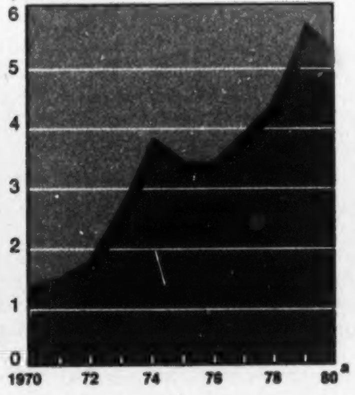
Annual sales

$ Billions



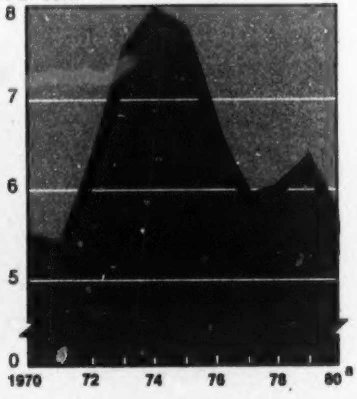
Annual earnings

$ Billions



Annual profit margins

Per cent



[a] C&EN estimates. **Note:** All sales, earnings, and profit margin data are based on the combined performance of the 40 largest chemical makers listed on page 10.

Second-quarter earnings dropped 12%, causing profit margins to fall to 5.6%

	SECOND-QUARTER 1980						FIRST-HALF 1980			
	Sales	Earnings	Change from 1979		Profit margin[a]		Sales	Earnings	Change from 1979	
	($ millions)		Sales	Earnings	1980	1979	($ millions)		Sales	Earnings
Du Pont[e]	3,412.3	176.6	5	−34	5.1	8.3	6,980.2	421.0	11%	−18%
Dow Chemical	2,522.7	171.2	9	−20	6.8	9.3	5,332.2	401.7	22	3
Union Carbide[f]	2,370.9	149.9	4	−16	6.3	7.8	4,936.5	369.8	11	11
Monsanto	1,548.6	23.2	1	−61	1.5	3.9	3,371.1	187.4	7	−15
W. R. Grace[g]	1,541.4	86.7	13	47	5.6	4.4	2,905.5	151.9	15	53
Allied Chemical[h]	1,364.1	73.0	45	40	5.4	5.5	2,748.3	141.2	54	59
American Cyanamid	837.0	32.6	5	−25	3.9	5.4	1,667.0	70.6	8	−16
Celanese	803.0	25.0	−1	−44	3.1	5.6	1,650.0	61.0	6	−21
Diamond Shamrock	769.1	56.3	34	6	7.3	9.2	1,524.5	112.6	41	36
PPG Industries	753.7	39.7	−4	−31	5.3	7.4	1,550.0	94.4	3	−12
B. F. Goodrich	749.9	10.0	0	−59	1.3	3.3	1,520.0	30.0	1	−40
Hercules	624.0	26.9	6	−33	4.3	6.8	1,269.0	60.6	11	−21
Williams Cos.	574.1	52.3	9	96	9.1	5.1	1,053.9	87.4	11	155
International Minerals[i]	499.5	35.9	14	−2	7.2	8.3	959.0	82.9	18	20
Olin	483.4	27.2	2	−1	5.6	5.8	958.7	49.2	5	10
Rohm & Haas	467.1	27.0	10	−1	5.8	6.4	902.8	54.2	11	−2
Ethyl Corp.[j]	440.5	24.1	7	−8	5.5	6.4	879.1	45.3	12	−4
Stauffer Chemical	357.1	20.0	3	−20	5.6	7.2	940.0	89.7	11	3
Air Products	356.9	26.9	16	8	7.6	8.1	734.1	61.2	21	24
Pennwalt[k]	292.4	10.9	8	−22	3.7	5.2	595.2	23.2	12	−3
Akzona	244.4	1.4	3	−71	0.6	2.1	537.6	6.8	8	−53
Lubrizol	243.1	29.5	28	30	12.1	12.0	466.3	58.4	33	45
Texasgulf[l]	240.6	59.1	18	83	24.6	15.9	520.6	136.7	38	137
Reichhold Chemicals	213.2	0.2	−6	−97	0.1	2.6	449.5	4.4	4	−48
Thiokol	153.2	7.7	5	−7	5.0	5.7	308.1	17.3	10	11
Nalco Chemical	150.2	17.6	10	13	11.7	11.4	297.6	33.8	9	9
Freeport Minerals	147.6	29.8	20	18	20.2	20.7	304.0	65.1	33	43
International Flavors	123.4	19.0	10	6	15.4	16.1	245.2	37.3	15	11
Mallinckrodt	109.4	9.1	9	11	8.3	8.2	221.4	18.1	12	15
Liquid Air[m]	103.3	6.4	6	−9	6.2	7.2	210.2	14.6	20	22
First Mississippi	95.1	8.8	35	76	9.3	7.1	137.2	13.3	29	90
Petrolite	64.6	6.9	34	50	10.7	9.6	124.1	12.1	37	44
Crompton & Knowles	61.1	2.4	−3	26	3.9	3.0	122.9	4.5	0	41
Beker Industries	57.5	5.7	18	307	9.9	2.9	132.0	16.5	35	650
Loctite	51.7	6.0	11	−8	11.6	14.0	102.4	12.3	17	0
Virginia Chemicals	37.8	0.0	12	−99	0.1	5.3	78.0	1.5	17	−58
Stepan Chemical	37.6	1.4	3	−25	3.7	6.5	77.0	2.0	8	−41
Essex Chemical	37.5	1.3	16	−28	3.5	5.6	70.9	2.1	16	−32
Great Lakes	27.2	3.9	−12	−12	14.3	14.5	61.6	9.3	1	6
Lawter Chemicals	19.5	3.1	17	13	15.6	16.3	39.7	6.3	18	13
Total 20 largest companies[o]	**$20,768.1**	**$1091.0**	**8%**	**−16%**	**5.2%**	**6.8%**	**$42,476.9**	**$2591.0**	**14%**	**2%**
Total 20 other companies[o]	**$2,218.0**	**$219.4**	**11%**	**22%**	**9.9%**	**9.[illegible]%**	**$4,506.3**	**$468.6**	**18%**	**41%**
GRAND TOTAL[o]	**$22,986.1**	**$1,310.4**	**9%**	**−12%**	**5.6%**	**7.0%**	**$46,983.2**	**$3,059.6**	**15%**	**7%**

a After-tax income as percentage of sales. b For 12 months ending second-quarter 1980. c Fully diluted before nonrecurring items and extraordinary charges for continuing operations. d As of July 31. e Excludes nonrecurring charge of $35.1 million in second-quarter 1979. f Excludes $217.3 million gain for accounting changes in first-quarter 1980. Since previous quarters were not restated, 12-month profit margins are not comparable. 12-month earnings per share and price-earnings-ratio for Union Carbide are approximate. g Grace had $3.5 million nonrecurring loss in second-quarter 1980 and $2.0 million gain in second-quarter 1979 on divestments. h Allied Chemical had $12.7 million charge against earnings in second-quarter 1979. i International

the economy continues to slow, profit gains in the third quarter will become increasingly difficult."

And at Stauffer Chemical, chairman H. Barclay Morley says there will be continued depressed demand in U.S. chemical operations this year. Even though Stauffer's fourth quarter is expected to benefit from seasonal foreign and domestic shipments, the uncertain length and depth of the recession make it difficult to forecast overall results for the year, according to Morley.

Fibers continued to suffer during the quarter, and plastics suddenly took a downturn. For example, Celanese showed a loss of 10 cents a share in its U.S. nylon and polyester business, but this was buffered somewhat by gains in cellulosics and non-U.S. fibers. Monsanto had a $41.4 million loss in operating income in textiles for the quarter, although this was less than half the $91.5 million loss shown in the second quarter last year.

Producers are hesitant to predict a turnaround in fibers. Edward L. Hennessy Jr., Allied Chemical's chairman, says that he does not expect significant improvement in the fibers market this year.

Plastics suffered perhaps even more than fibers on a percentage-decline basis. B. F. Goodrich, the country's largest producer of polyvi-

FIRST-HALF 1980		12-MONTH RUNNING DATA^b				Earnings per share^c		STOCK MARKET DATA^d		
Profit margin^a		Change from 1979		Profit margin^a						
1980	1979	Sales	Earnings	1980	1979	2nd qtr	Recent 12 months	Stock price	Price-earnings ratio July 31	Dividend yield, % of price
6.0%	8.2%	15	−7	6.6	8.1	1.19	5.88	43	7	4.7
7.5	8.9	30	17	7.8	8.7	0.94	4.10	36½	9	4.4
7.5	7.5	13	34	6.7	5.7	2.25	10.40	43¾	4	7.3
5.6	7.0	14	−26	4.5	6.9	0.64	7.90	55⅜	7	6.5
5.2	3.9	18	51	4.8	3.8	1.80	5.42	43¾	8	5.3
5.1	5.0	61	41	4.3	4.9	2.02	6.92	51¼	7	4.3
4.2	5.4	11	−5	4.7	5.5	0.68	3.17	28	9	5.7
3.7	5.0	12	−14	3.9	5.0	2.93	9.67	53	5	6.8
7.4	7.6	39	32	7.4	7.9	1.03	3.89	31⅝	8	5.1
6.1	7.1	6	2	6.6	6.9	1.21	6.31	35⅜	6	6.1
2.0	3.4	8	−35	1.9	3.1	0.57	3.32	21⅞	7	7.1
4.8	6.7	15	−7	5.2	6.5	1.38	3.67	19¼	5	6.2
8.3	3.6	19	248	6.3	2.2	1.92	4.49	35¼	8	3.1
8.6	8.5	21	24	8.3	8.2	1.34	7.40	41	6	5.7
5.1	4.9	7	−3	4.1	4.6	1.13	3.20	20⅛	6	5.0
6.0	6.8	18	26	5.9	5.5	2.10	7.63	47⅜	6	4.9
5.2	6.1	15	5	5.4	6.0	1.17	4.65	31⅜	7	4.8
9.5	10.3	13	1	8.5	9.6	0.45	3.10	19⅞	6	6.0
8.3	8.1	21	26	8.2	7.9	0.95	4.04	45	11	1.8
3.9	4.5	16	−2	4.1	4.8	1.06	4.61	29¾	6	7.4
1.3	2.9	14	8	2.4	2.5	0.12	1.37	10¼	7	7.8
12.5	11.5	29	31	12.7	12.5	1.52	5.61	66¾	12	2.7
26.3	15.3	32	148	22.7	12.1	1.58	5.60	41⅛	7	3.9
1.0	2.0	10	−43	0.9	1.8	−0.08	0.75	11¼	15	4.3
5.6	5.5	7	21	6.7	5.9	0.66	3.18	52½	17	3.0
11.4	11.3	14	11	11.0	11.3	0.88	3.21	40½	13	4.0
21.4	20.0	47	85	21.0	16.7	0.95	4.64	47	10	2.1
15.2	15.7	13	9	14.8	15.3	0.52	1.79	23¾	13	3.9
8.2	7.9	11	17	8.2	7.9	0.92	3.55	36½	10	3.3
6.9	6.8	21	7	5.3	6.0	0.60	2.74	26¼	10	5.3
9.7	6.6	36	349	8.7	2.6	1.02	2.35	40¾	17	1.2
9.8	9.3	24	16	8.7	9.4	1.17	3.26	65	20	1.9
3.7	2.6	2	26	3.6	2.9	1.07	3.67	23	6	5.2
12.5	2.2	31	n	10.4	n	0.49	2.35	15½	7	—
12.0	14.1	23	11	13.0	14.4	0.61	2.53	34⅞	14	1.6
1.9	5.4	19	−57	1.5	4.1	0.01	0.80	13¼	17	5.1
2.6	4.8	14	−25	2.6	3.9	0.76	1.69	17½	10	5.3
3.0	5.1	17	19	15.4	15.1	0.56	2.38	47⅞	20	0.8
15.1	14.3	19	−34	2.8	5.1	0.56	1.64	11⅞	7	6.7
15.8	16.5	18	15	15.9	16.7	0.27	1.03	11¾	11	5.1
6.0%	**6.8%**	**16%**	**9%**	**6.1%**	**6.4%**					
10.4%	**8.7%**	**19%**	**51%**	**9.9%**	**7.8%**					
6.5%	**7.0%**	**16%**	**14%**	**6.4%**	**6.6%**					

Minerals had net charge $4.3 million in second quarter. j Ethyl had $6.8 million charge in second-quarter 1980 and $7.3 million nonrecurring gain in first quarter. k Pennwalt had $2.6 million nonrecurring gain in second-quarter 1979. l Texasgulf had $4.1 million gain in second-quarter 1980 from change in accounting methods. m Liquid Air had $2 million gain in second quarter on sale of assets. n Deficit. o Averages except for sales and earnings.

nyl chloride resin, says that following the precipitous decline in new housing starts and other construction activity, U.S. industry shipments of PVC declined 30% compared to the first quarter. Carbide's plastics sales declined 3% for the quarter. Although not disclosed, the earnings decline probably was much larger because of higher raw material costs.

At Monsanto, sales of plastics and resins declined 15.8% during the quarter from the same period a year ago. Operating (pretax) income dropped to a loss of $13.3 million this year from $9.7 million last year.

The one remaining semibright spot for the chemical industry thus far seems to be foreign business. Carbide's Sneath says that foreign sales were up 13% for the quarter. G. J. Williams, financial vice president at Dow, comments that Latin America and some countries in Europe are showing continued strength. And at Loctite, E. Russell Eggers, president and chief executive officer, says that strong growth in Loctite's international sales and earnings did much to cushion the impact of the developing recession in the U.S.

Good non-U.S. business also was helpful for some of the more diversified U.S. chemical producers in the second quarter. For example, NL Industries says that European and Ca-

Earnings jump again at oil companies but not at diversified chemical producers

		2ND-QUARTER 1980						FIRST-HALF 1980		
	% chemical sales	Sales	Earnings	Change from 1979		Profit margin[a]		Sales	Earnings	Change from 1979
		($ millions)		Sales	Earnings	1980	1979	($ millions)		Sales
OIL AND GAS COMPANIES										
Exxon	8%	$26,223.0	$1,030.0	41%	24%	3.9%	4.5%	$53,877.0	$2,955.0	44%
Mobil[b]	3	15,300.0	688.0	43	64	4.5	3.9	30,600.0	1,533.0	46
Texaco[b]	3	12,539.0	502.9	47	49	4.0	4.0	25,788.0	1,103.5	53
Standard Oil of California	3	10,649.0	535.0	53	40	5.0	5.5	21,096.0	1,162.0	51
Standard Oil (Ind.)	10	7,291.0	488.2	57	39	6.7	7.6	13,742.5	1,064.2	52
Gulf Oil[b]	9	6,800.0	370.0	11	27	5.4	4.8	14,556.0	759.0	25
Atlantic Richfield	10	5,642.2	434.8	51	67	7.7	7.0	11,075.9	860.9	53
Shell Oil	16	4,895.0	407.0	44	47	8.3	8.1	9,693.0	780.0	50
Conoco	6	4,700.0	249.6	57	16	5.3	7.2	9,000.0	578.0	55
Phillips Petroleum	20	3,230.0	214.8	45	0	6.7	9.8	6,610.0	499.3	57
Tenneco	13	3,201.0	186.0	18	22	5.8	5.7	6,517.0	364.0	27
Sun Co.	3	3,000.0	247.0	20	48	8.2	6.7	6,100.0	498.3	24
Occidental Petroleum	22	2,998.6	161.1	34	52	5.4	4.7	6,345.2	439.0	56
Standard Oil (Ohio)	5	2,800.0	451.3	56	124	16.1	11.2	5,500.0	902.0	57
Union Oil	11	2,751.4	194.8	47	52	7.1	6.9	5,127.0	347.7	41
Getty Oil	3	2,643.3	243.1	130	74	9.2	12.1	4,912.0	469.0	119
Ashland Oil[b]	13	2,121.8	47.7	17	−5	2.3	2.8	4,121.0	95.1	25
Cities Service	8	1,814.3	107.0	27	40	5.9	5.4	3,986.3	277.1	39
El Paso	11	924.5	6.1	23	−85	0.7	5.4	1,952.9	40.9	45
Kerr-McGee	16	854.2	49.6	32	14	5.8	6.8	1,634.6	96.7	31
DIVERSIFIED MANUFACTURERS										
Engelhard Minerals	1	6,684.4	139.1	74	136	2.1	1.5	12,619.0	280.5	89
General Electric	2	6,200.0	402.6	10	5	6.5	6.8	12,080.0	744.1	13
U.S. Steel[b]	9	3,100.0	111.5	−14	−26	3.6	4.2	6,300.0	222.7	−6
Eastman Kodak	20	2,130.7	272.5	18	22	12.8	12.4	4,267.7	488.4	24
Goodyear	12	2,071.3	43.1	−3	−19	2.1	2.5	4,094.8	93.8	−1
Esmark	8	1,772.2	26.0	4	11	1.5	1.4	3,424.9	47.4	6
3M	15	1,518.0	157.3	13	−3	10.4	12.0	3,012.0	324.6	14
Aluminum Co. of America[b]	9	1,290.6	121.5	9	0	9.4	10.4	2,593.1	265.0	9
Firestone[b]	13	1,286.1	−3.0	−5	c	c	2.4	2,463.3	−16.8	−4
Borden	34	1,276.3	39.7	14	8	3.1	3.3	2,346.4	70.3	13
Georgia-Pacific	10	1,197.0	55.0	−11	−42	4.6	7.1	2,422.0	105.0	−1
Kaiser Aluminum	14	939.0	82.2	17	38	8.8	7.4	1,689.1	155.7	12
FMC	34	875.7	39.3	3	−10	4.0	5.1	1,749.1	80.1	8
Pfizer	14	734.5	57.6	8	3	7.8	8.3	1,444.6	123.0	10
Northwest Industries	7	684.5	31.6	7	−30	4.6	7.0	1,341.8	62.1	9
Merck	16	674.8	114.9	13	11	17.0	17.2	1,329.8	220.9	14
Borg-Warner	22	669.6	31.5	−6	−27	4.7	6.1	1,349.0	67.4	1
North American Philips[b]	14	656.4	16.3	6	−19	2.5	3.3	1,248.8	32.3	7
Martin Marietta	12	643.8	58.8	23	9	9.1	10.3	1,210.9	93.3	26
Eli Lilly	21	599.9	78.3	8	−10	13.1	15.7	1,317.5	194.7	12
Uniroyal	23	593.2	−2.6	−18	c	c	c	1,173.4	−14.7	−18
Dart Industries[b]	26	565.5	44.9	−9	7	7.9	6.7	1,125.0	81.1	−6
General Tire	21	529.9	6.9	−12	−79	1.3	5.4	1,043.3	−4.4	−7
National Distillers[b]	37	512.7	29.6	−1	−3	5.8	5.9	1,071.2	72.7	1
NL Industries[b]	30	510.3	39.8	11	36	7.8	6.4	1,016.0	76.3	16

a After-tax income as percentage of sales. b Excludes major nonrecurring earnings; Mobil—$459 million in first-quarter 1980; Texaco—$402 million in first-quarter 1980; Gulf Oil—$100 million in second-quarter 1980; Ashland Oil—$345.1 million in second-quarter 1979. $3.4 million loss in first-quarter 1979; U.S. Steel—$14.8 million in first-quarter 1980 and $90.4 million in first-quarter 1979; Alcoa—$27.3 million in second-quarter 1979 and $12.3 million in second-quarter 1979; Firestone—$49 million charge in second-quarter 1980; North American Philips—$3.6

FIRST-HALF 1980			STOCK MARKET DATA							
Change from 1979	Profit margin[a]		Earnings per share		Stock price			Price-earnings ratio July 31	Annual indicated dividend	Dividend yield, % of price
						Recent 12 months				
Earnings	1980	1979	2nd qtr	Recent 12 months	July 31	High	Low			
66%	5.5%	4.8%	$2.36	$12.46	69⅝	72¾	52	6	$5.60	8.0%
77	5.0	4.0	3.24	12.97	74¼	89½	38	6	3.40	4.6
72	4.3	3.8	1.87	8.20	36¼	41⅝	27	4	2.40	6.6
60	5.5	5.2	3.13	12.99	74½	89	45¾	6	3.60	4.8
52	7.7	7.8	1.68	6.37	58⅞	65	46	9	2.20	3.7
41	5.2	4.6	1.90	7.90	40	54½	26¾	5	2.50	6.3
71	7.8	6.9	1.75	5.60	45	50½	43	8	1.90	4.2
56	8.1	7.7	1.32	4.56	36⅜	40¾	34	8	1.40	3.9
53	6.4	6.5	2.32	9.44	53¾	59	37⅞	6	2.20	4.1
27	7.6	9.3	1.41	6.49	41	61⅛	37	6	1.80	4.4
32	5.6	5.4	1.52	5.80	41	45½	31¼	7	2.40	5.9
69	8.2	6.0	1.95	7.17	37⅞	40⅞	33¼	5	1.80	4.8
133	6.9	4.6	1.87	9.69	26¼	31⅞	19	3	2.00	7.6
145	16.4	10.5	1.83	7.05	45	52½	42¼	6	1.40	3.1
43	6.8	6.7	2.25	6.99	56½	62½	37½	8	1.60	2.8
89	9.6	11.0	2.95	10.03	82¾	97¾	51½	8	1.80	2.2
23	2.3	2.4	1.57	6.62	36	42¾	25¾	5	2.20	6.1
79	7.0	5.4	1.29	5.65	33¼	39⅜	29⅜	6	1.60	4.8
−43	2.1	5.3	0.13	2.29	20⅜	30½	15¾	9	1.48	7.3
26	5.9	6.2	1.91	6.93	74⅛	85	52	9	1.80	2.4
163	2.2	1.6	2.03	7.60	41⅜	42½	20⅛	5	1.16	2.8
9	6.2	6.4	1.77	6.45	56¼	57½	44	9	3.00	5.3
13	3.5	2.9	1.28	−3.15	24	24½	16¼	c	1.60	6.7
16	11.4	12.2	1.69	6.63	61¼	62⅝	42⅞	9	2.40	3.9
−13	2.3	2.6	0.59	1.83	15¼	16¼	10¾	8	1.30	8.5
16	1.4	1.3	1.14	4.54	49¾	49⅞	24½	11	1.84	3.7
3	10.8	11.8	1.34	5.68	58¾	59⅜	46¼	10	2.80	4.8
6	10.2	10.5	3.40	14.36	69	70⅞	48⅜	5	3.20	4.6
c	c	2.6	−0.05	0.32	8	12¾	6⅛	25	0	0
7	3.0	3.2	1.21	4.25	26	27⅞	19⅝	6	1.90	7.3
−39	4.3	7.0	0.51	2.42	29⅛	34⅞	21½	12	1.20	4.1
35	9.2	7.7	1.87	6.19	25	25⅝	15⅜	4	1.40	5.6
−3	4.6	5.1	1.08	4.12	25¼	31⅛	21⅝	6	1.40	5.5
7	8.5	8.7	0.79	3.36	42⅞	44⅝	30⅝	13	1.44	3.4
−21	4.6	6.5	1.02	5.03	30¾	37⅞	24¾	6	2.28	7.4
14	16.6	16.6	1.53	5.43	77¼	78¼	58¼	14	2.30	3.0
−14	5.0	5.8	1.47	6.75	37¾	42⅞	29¾	6	2.30	6.1
−4	2.6	2.9	1.20	5.54	31⅜	32	23½	6	1.70	5.4
8	7.7	9.0	2.36	7.41	54¾	57⅜	34¼	7	2.32	4.2
2	14.8	16.2	1.04	4.58	54⅜	63⅞	45¾	12	2.10	3.9
c	c	0.2	−0.10	−1.89	4¼	6	3⅛	c	0	0
6	7.2	6.4	1.70	5.87	42⅛	49⅝	35⅛	7	2.00	4.7
c	c	4.0	0.29	1.36	28¾	32½	22	21	2.00	7.0
16	6.8	5.9	0.86	3.84	49¾	51⅞	23⅞	13	1.20	2.4
52	7.5	5.7	1.17	4.02	27½	31¾	19	7	1.40	5.1

million in second-quarter 1979 and $5.1 million in first-half 1979; Dart Industries—$9.7 million in second-quarter 1980; National Distillers—$17 million in second-quarter 1979; NL Industries—$26.3 million in first-half 1979. c Deficit.

BEST AVAILABLE COPY

Petrochemical earnings at leading oil companies join the slide

True to their roller-coaster profits tradition, petrochemicals magnified the earnings downsweep in the U.S. chemical industry in the second quarter. While worldwide after-tax earnings at the largest basic chemical companies fell 12% in the quarter from second-quarter 1979, combined after-tax earnings for petrochemicals at seven major oil companies sank 25%.

Petrochemical earnings still managed an overall 14% gain for the first half of 1980 over first-half 1979 at these companies, and the reduced earnings of the second quarter still kept a fairly healthy profit margin on sales. However, the direction was clear, and bad. Since leading petrochemical prices have suffered further discounts in the third quarter, and since foreign economies are rapidly joining the U.S. recession, petrochemical earnings' plunge probably will continue for a while.

"Declines occurred both in the U.S. and abroad as a result of softer margins and lower sales volume," says C. C. Garvin Jr., chairman of Exxon, about second-quarter petrochemical earnings. Exxon is the leading petrochemical producer and ranks third among all U.S. chemical producers behind Du Pont and Dow Chemical. "In the U.S., where second-quarter earnings were only one half those of the first quarter, [physical] sales volume was 16% lower."

On first-half petrochemical performance, Garvin notes Exxon's 24% earnings improvement over first-half 1979. But that was thanks to good earnings outside the U.S. "Foreign earnings were up 73% from improved margins. Margins also were higher in the U.S., but the earnings effect was more than offset by increased operating expenses; earnings in the U.S. declined 17%. Worldwide [physical] sales volume of chemical products declined 3%."

Conoco's second-quarter report also complains of lower chemical sales volumes. At Gulf Oil, the comment is that U.S. product prices and sales volumes for major petrochemicals and plastics eroded sharply in June as the recession deepened.

Bits of product data from companies hint the severity of the physical volume drop. For example, Cities Service says that its sales of petrochemical intermediates were about 235 million lb in the second quarter, down 14% from second-quarter 1979 and down 28% from first-quarter 1980. Gulf Oil says that its worldwide chemical sales were 3.1 billion lb in the second quarter of 1980, off 9% from both second-quarter 1979 and first-quarter 1980.

Even so, petrochemical profitability was still respectable in the second quarter, a few other company reports indicate. For example, Shell Oil's chemical segment income (after taxes but before corporate overhead) was 7.1% of chemical revenues in the second quarter although down from 9.0% a year ago.

AFTER-TAX EARNINGS

$ Millions	Second quarter 1980	Second quarter 1979	Second quarter % change	First half 1980	First half 1979	First half % change
Conoco	$ 18.2	$ 23.8	−24%	$ 43.7	$ 37.3	17%
Exxon	107.0	127.0	−16	269.0	217.0	24
Gulf Oil	56.0	75.0	−25	127.0	114.0	11
Mobil	26.0	34.0	−21	62.0	59.0	5
Shell Oil	54.0	59.0	−8	77.0	73.0	5
Standard Oil (Ind.)	46.1	77.2	−40	105.3	90.6	16
Texaco	9.1	23.5	−61	39.2	40.8	−4
TOTAL	$316.4	$419.5	−25%	$723.2	$631.7	14%

nadian titanium pigment results were the main reason for a 12% year-to-year earnings gain in its chemical operations. However, NL adds that overall demand weakness in chemicals late in the quarter probably will reduce its chemical earnings in the second half of 1980.

A few other solid increases in chemical earnings dot the generally negative reporting of other diversified companies on chemical operations. One of these was Uniroyal, which is under financial siege in its tire operations. Chemicals at Uniroyal increased their operating (pretax) profit 16% in the second quarter from a year ago on a 9% sales gain.

Another example might be Eastman Kodak's chemicals division, which had a 14% sales increase led by fibers and plastics in the second quarter from second-quarter 1979. However, Eastman Kodak says nothing about chemical earnings.

At other companies, widespread reports of second-quarter earnings weakness in polymers indicate that gains in sales didn't necessarily make it to the bottom line. For example, National Distillers, in explaining a drop in its chemical earnings for the second quarter from a year ago, mentions "substantial volume declines for all major products" and "increased petrochemical raw materials costs."

More specifically, Distillers adds, "Selling prices for the important polyethylene products weakened late in the quarter, and this trend is continuing." Distillers also says that low operating rates and sporadic operations at its new synthesis-gas-based complex outside Houston hurt earnings. Distillers and partner Du Pont have been starting up units at this complex over the past year.

The end markets most responsible for trouble in polymers and other chemical products in the second quarter were the familiar hard-pressed durables—autos and housing. A typical comment comes from Borg-Warner chairman James F. Bere, who says the company's first year-to-year earnings decline in five years came in the second quarter at the hands of poor transportation and housing markets.

At Georgia-Pacific, chairman Robert E. Flowerree says, "We've had some weakness in chemicals associated with the construction industry, like thermosetting resins and some of their feedstocks, as well as polyvinyl chloride resin." However, he says, "Other chemical lines such as methanol and ammonia are running at capacity with excellent demand and firm prices."

Georgia-Pacific's luck with agriculturally oriented ammonia was shared by some other diversified chemical producers such as Kaiser Aluminum & Chemical in the agricultural market sphere. But more reports of earnings damage in this area are cropping up. For example, Eli Lilly says that sales of its Treflan herbicide declined in the second quarter from a year ago because of adverse weather and lower acreage in some parts of the U.S. and Canada.

At Northwest Industries, operating (pretax) earnings fell 79% at pesticides-producing Velsicol, its chemical segment, in the second quarter from a year ago. FMC also says earnings and sales fell in agricultural chemicals from second-quarter 1979.

Hence, agriculture, a formerly safe earnings haven, has joined durables and other markets as a trouble spot for many companies. For the future, the third quarter is too early for any earnings relief as may be the fourth. Rates of decline appear to be easing, but recovery is not yet in sight. □

Canadian chemicals feel the recession

Earnings were up for three of four largest firms in second quarter and first six months, but growth rate has slowed considerably from last year

Like their U.S. counterparts, Canada's four largest publicly reporting chemical companies—C-I-L Inc., Celanese Canada, Du Pont Canada, and Union Carbide Canada—are being squeezed by the recession. Although three of the four still could boast of higher earnings for the second quarter and the first six months than in the previous year's comparable period, it was evident that the growth rate was slowing.

Combined second-quarter sales of the four firms was almost $812 million (Canadian), a 12% increase from second-quarter 1979. Net income for the four reached $58.3 million, a 30% gain. For the first half, sales totaled $1.58 billion, up 16% from the 1979 period. Earnings came to nearly $109 million, up 54%. That sounds pretty good, but it's skewed by disparities among the companies, and it's a sharp comedown from the over-100% quarterly gains that were typical of much of 1979. Profit margins held up fairly well; return on sales averaged 6.9% for the four companies, with a range of 5.4% to 11.2%.

C-I-L's second-quarter sales amounted to more than $282 million, a 10% increase from the like 1979 period. Net income increased 18% to $19.4 million. For the first six months, sales totaled more than $510 million, up 12% from first-half 1979. Net income for the period was $29.0 million, up 42%.

According to C-I-L president W. J. Mandry, sales gains in most major lines, together with improved operating efficiency, more than offset rising material and manpower costs. However, effects of the economic slowdown began to appear late in the second quarter, with prices and demand softening in several important business areas. But sales and earnings for the full year are still expected to be "comfortably ahead of 1979."

For companies with heavy involvement in fibers and textiles, the downturn had become evident earlier. At Celanese Canada, for example, second-quarter sales of more than $100 million represented a 12% increase from the second quarter of 1979. But net income came to only $5.5 million, a 13% decline. For the first six months, sales reached almost $200 million, a 14% increase, but earnings declined 5%, to $10.7 million. Celanese president Richard M. Clarke calls the results satisfactory, considering the overall state of the economy.

Things were a little better at Du Pont Canada, but earnings growth was down sharply compared to the company's strong recovery in 1979. Second-quarter sales rose 11% from the corresponding 1979 period, to almost $248 million, but net income rose only 4.2%, to $13.6 million. In the first half, sales totaled about $482 million, up 16% from the first half of 1979, and earnings came to $26.2 million, up 21%.

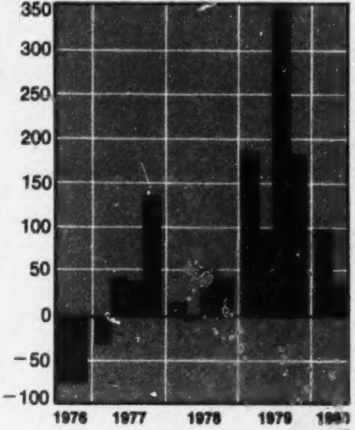
President J. E. Newall notes that demand for many Du Pont products dropped in the second quarter, with fibers activity particularly affected by slower business and by startup costs at a Quebec polyester plant.

At Union Carbide Canada, the recession usually hits later, and this year seems to be no exception. Carbide sales amounted to more than $181 million in the second quarter, 16% ahead of last year's second quarter. Net income rose a healthy 127% to $19.8 million. For the first six months, sales reached $384 million, a 24% gain from the like 1979 period. Earnings came to $42.9 million, a 150% increase from the 1979 period (when Carbide wasn't doing so well) and a return on sales of a little better than 11%. The company points out, however, that about 23% of the apparent earnings improvement resulted from various changes in accounting procedures.

Most product lines had first-half sales gains, Carbide notes, with carbon products particularly strong. Exports increased 33%, to $44.4 million. The downturn will "moderate" second-half results, according to Carbide president J. S. Dewar. But he still expects full-year earnings to exceed 1979's, even without the accounting change benefits.

Ward Worthy, Chicago

Earnings growth rate shows downward trend



[a] After-tax earnings of four largest publicly reporting Canadian chemical companies—Celanese Canada, C-I-L, Du Pont of Canada, and Union Carbide Canada.

Return on sales holds up fairly well in first half

	First six months, 1980					
$ Millions (Canadian)	Net sales	Change from 1979	Net income	Change from 1979	Profit margin[a] 1980	Profit margin[a] 1979
C-I-L Inc.	$ 510.1	13%	$ 29.0	42%	5.7%	4.5%
Celanese Canada	199.6	14	10.7	−5	5.4	6.5
Du Pont Canada	482.3	16	26.3	21	5.4	5.2
Union Carbide Canada	384.0	24	42.9	150	11.2	5.5
TOTAL	$1576.1	16%	$108.8	54%	6.9%	5.2%

a Net income as percentage of sales.

Uncertain science pushes Love Canal solutions to political, legal arenas

Lois R. Ember
C&EN, Washington

> ***"The important scientific problems at Love Canal are that little is known about the toxicity of the chemicals, and that it is difficult to use health surveys and epidemiological studies to associate exposure to chemicals from dump sites with human health effects. We do not have markers that help us associate disease with prior chemical exposure. Moreover, in a statistical sense, most dump areas impact on the health of relatively few people, and it is difficult to detect relatively rare events in small populations. Because we can't generalize about the toxic effects of multiple chemical exposure, it is almost impossible to estimate the health impacts of such exposure other than to assume that they are simply additive."***
>
> ***—David Rall, director, National Institute for Environmental Health Sciences***

Love Canal is the nation's first notorious episode of land pollution. This violated chemical grave haunts the residents of the area, stalks the company that buried the wastes, and tests the mettle of governments charged with protecting their citizens and the environment. In short, the precedent-setting potential of Love Canal has hampered efforts toward a permanent solution to the cleanup of the landfill, the speedy relocation of residents, and the execution of well-designed health and environmental studies.

As the first chemical dump to release its toxic legacy, it is fitting that Love Canal is located in that part of New York state known as the Niagara Frontier. Resolution of the not-so-mute medical, legal, and moral issues swirling about Love Canal will extend the frontiers of environmental health, the law, and corporate responsibility.

Testing the frontiers of events has always been Love Canal's hallmark. William T. Love, a turn-of-the-century entrepreneur, tested his dream there. He would build a navigable power canal connecting the upper and lower levels of the Niagara River, and this 7-mile-long trough producing cheap electricity would bring industry and commerce to his planned model city. His dream, however, never materialized. An economic depression and the invention of alternating current contrived to stifle it after only 3000 feet of his canal had been dug. For the next 30 years, the canal, one-quarter mile from the Niagara River, served only as the neighborhood swimming hole.

Then in 1942 Hooker Electrochemical Corp. (now Hooker Chemical & Plastics, a subsidiary of Occidental Petroleum Corp.) obtained permission to dispose of its chemical wastes in the canal. In 1947 it bought the 16-acre property. And for 11 years until 1953, when it deeded the land to the Niagara Falls Board of Education for a token $1.00, the company used Love Canal as a burial vault for more than 21,000 tons of its wastes.

It wasn't a final resting place for this chemical soup. Twenty-five years later, excessive rains and melting snow penetrated the canal's cover, and the rising water table carried the "Love Canal leachate," a sweetly aromatic, oily black ooze, out of its grave and into the backyards and basements of homes that had been built adjacent to the landfill.

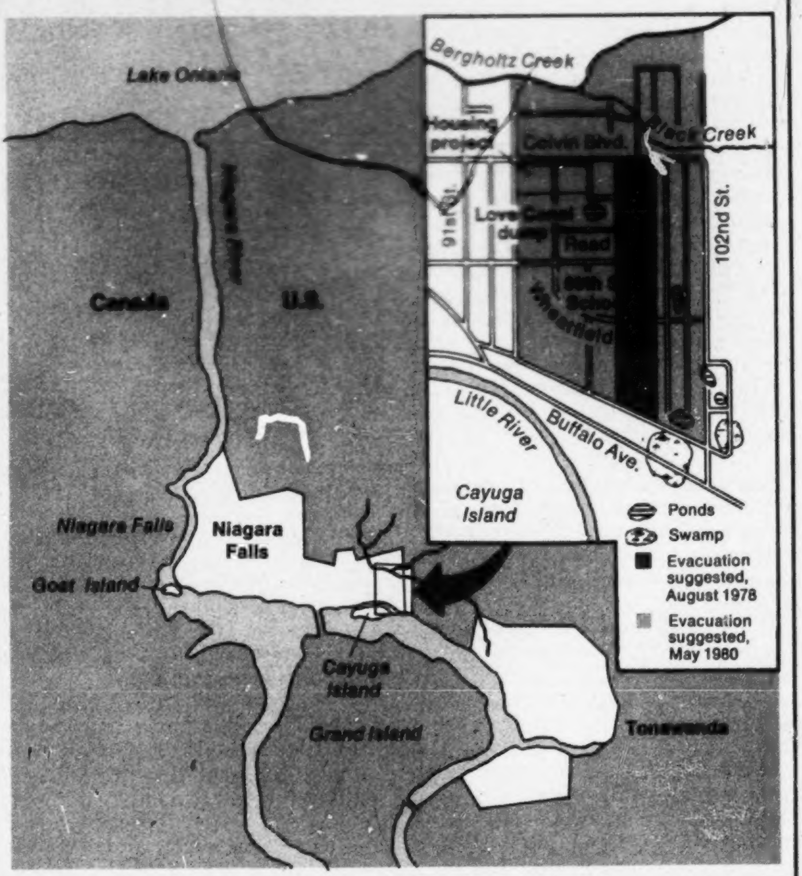
The canal residents believed that the chemical ooze brought disease and death, and they lobbied for relief. In August 1978 relief came, after 82 chemicals, 11 of them suspected human carcinogens and one—benzene—a known human carcinogen had been identified by New York state and the Environmental Protection Agency in air, water, and soil. Some 239 families in the first two rings of homes bordering the canal were evacuated, their homes were purchased by the state, the 99th St. School built over the center of the landfill was closed, and a six-block area was cordoned off by an 8-foot-high chain link fence.

Since then additional environmental and medical studies, some under dispute, have tracked chemical migration and disease beyond the 1978 evacuation lines. Attendant publicity has made the homes caught in the ever widening net worthless, and area citizen groups, of which the Love Canal Homeowners Association is the most vocal and effective, have been clamoring for permanent relocation. But caught in bureaucratic cross fire, the residents remain in economic, medical, and legal limbo. Migrating toxic chemicals plus government ineptness have not brought them evacuation, only fear, frustration, and a nightmare beyond their control.

Mounting strain in the community may account for many of the illnesses reported by the residents. Unfortunately, it is not yet possible to separate chemical-induced illness from stress-induced disease. In the absence of sound medical science, anecdotal evidence fills the void. This evidence fuels the residents' fears and further adds to psychological stress.

At this point, the only humanitarian gesture left is to evacuate the additional 710 families covered by President Carter's May 21 declaration of a health emergency at Love Canal, say Rep. John J. LaFalce, whose district includes the Love Canal area, and New York Gov. Hugh Carey. Cynical but realistic, the residents expect to be moved out in this Presidential election year. Their expectation may be realized soon. Just

Love Canal dump affects a widening area



two weeks ago, the federal government offered the state a long-term $15 million loan at 8.25% interest. The state was cool to this offer, but dickering is going on. Once the residents are assured of permanent relocation, they may be more willing to participate in federal health and environmental monitoring studies.

Hooker, the company that buried the toxic chemical wastes, disavows all liability. It argues that it disposed of the chemicals in an impervious clay vault using state-of-the-art techniques for the period. Hooker also says that under threat of eminent domain, it transferred the property to the school board, which wanted to build a school on it, and that the deed of conveyance contained a paragraph warning that the landfill had been filled with "waste products resulting from the manufacturing of chemicals," and that Hooker disclaimed all liability for injuries occurring as a result of these "industrial wastes" after the property transfer. Furthermore, on subsequent occasions it went before the school board to warn it against construction on the property that might result in disturbance of the "dangerous chemicals" buried there.

Additionally, Hooker claims that before property transfer it placed over the landfill a clay covering whose integrity was later breached by the construction of city roads, an expressway, and the removal of thousands of cubic yards of dirt. By Hooker's analogy, precipitation penetrated the violated cover, and the buried chemicals rose with the water table, overflowing the canal banks like a stoppered, unattended bathtub.

Hooker will have to defend these claims in court. Compensatory and punitive damage suits brought against the company by New York state, the Justice Department on behalf of EPA, and 1300 private individuals total billions of dollars, with some estimates as high as $11 billion. Sophisticated analytical tools are dissecting the chemical miasma of Love Canal, but the courts will resolve the conflicting responsibilities and liabilities born of that miasma.

Unfortunately, as a result of litigation and governmental haggling and bungling, families are being destroyed and the social fabric of the community is being rent. This human suffering plus EPA's estimate of 32,000 to 50,000 other toxic waste sites in the U.S. have made Love Canal the rallying cry for superfund legislation to finance the cleanup of abandoned waste dumps. And to prevent a repetition of the ineptness that has characterized government response to Love Canal, EPA has assembled a "superfund task force" that is readying itself to respond to future hazardous waste episodes.

The time it has taken to parcel out blame, responsibility, and costs, though adding to mounting stress, has done little to uncover a relationship between exposure to toxic chemicals known to be buried in the canal and illnesses reported by the residents. Finding the tools to make this causal nexus strains both medical and environmental sciences and probes the frontiers of environmental health.

Sleuthing for causes of present day diseases that may have resulted from exposure to chemicals years before would tax even the skills of Sherlock Holmes, Still, New York and EPA have made fitful stabs at it over the past two years, and even now EPA and the Center for Disease Control (CDC) stand ready to mount more comprehensive and, it is hoped, better designed environmental and health studies. These await resident cooperation and permission to enter private homes.

Love Canal, quite simply, has been a learning experience, one in which traditional scientific tools and modes of inquiry have been found wanting. As the governments have worked their way through this learning maze, mistakes have been made, and inadequate explanations of findings have been given to the residents.

Government ineptitude, however, does not change the fact that toxic chemicals were placed in the ground by Hooker. And, although Hooker believed that its disposal practices were safe, neither it nor subsequent owners monitored the chemical grave in any regular fashion for decades. The lack of monitoring allowed migrating chemicals to go undetected for nearly 25 years.

Then in 1976 they literally surfaced. A tentative 1976 monitoring effort by the New York Department of Environmental Conservation, plus the "constant badgering" of Rep. LaFalce from 1977 on, set into motion the cavalcade of environmental and health studies that comprise the history of Love Canal. These studies—some limited in scope, others in hindsight, poorly designed, incorrectly or still not analyzed—became the basis for two health emergency declarations in two years.

The first, in August 1978, was state initiated and ordered remedial construction work to begin at the landfill to contain the chemicals. Because families living in homes built adjacent to the canal could be exposed to increased dangers, Gov. Carey ordered these families' permanent relocation. This set a precedent that 710 families affected by President Carter's May 1980 order hope to bank on in getting the federal government to buy their homes. Between these two orders, haggling intensified because neither the state nor the federal government wanted to claim ultimate responsibility for the care of the residents.

The first evacuation of 239 families raised the level of fear in the families remaining. Frequent testing, but infrequent or inadequate explanations of findings turned their fear to frustration. Frustration evolved into determination to get out. One exit ticket: Hold future tests hostage until a pledge of permanent removal is obtained. This standoff between big government and a besieged lower-middle-class community is the state of affairs today.

This situation was reached in traumatic jolts. Contamination became obvious in late 1977, and early 1978. Then, a black, oily scum containing pesticides, solvents, and other toxic chemicals lay in pools on the surface of the landfill. Residents' complaints of this chemical ooze in their backyards and basements prompted the state to call in EPA. In February 1978, EPA took air scans, mostly in the basements, of 14 homes abutting the canal and identified 26 organic compounds.

EPA's findings elicited an expanded effort by the state Department of Health in the spring. Air in all the homes on 97th and 99th Streets—the first two so-called rings surrounding the landfill—was sampled; water was collected from those homes that had sump pumps; soil samples from the landfill and around the homes were collected; leachate from the canal was taken for analysis. At the same time, a medical survey was conducted on these families; blood samples were also drawn.

The finding of 80 chemicals in the air, water, soil, and leachate plus a higher rate of miscarriages—more than 1.5 times the norm—and birth defects in families living around the southern part of the canal led to the state's declaration of a health emergency.

A separate epidemiological study was launched by the Love Canal Homeowners Association under the guidance of its scientific adviser, Beverly Paigen, a cancer research scientist at Roswell Memorial Park Institute in Buffalo, N.Y. Paigen apparently was able to correlate clusters of diseases—miscarriages, birth defects, respiratory illnesses, and others—with swale or wet areas. Swales, several of which cross the canal, are dried up streambeds that may serve as preferential routes of chemical migration from the canal.

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One man's dream becomes a neighborhood's continuing nightmare

C&EN staff photos

Her survey, not without flaws, was nevertheless found by a then-Health, Education & Welfare panel to merit further study and has, in part, been validated by an expanded state epidemiological survey. The state's study also correlated swales and other historic wet areas with higher rates of miscarriages, lowered birth weights and, possibly, elevated rates of birth defects.

Raw data from this epidemiological study have not been made public; the state argues patient confidentiality. EPA, Hooker, the home owners association, and others have all sought the data. A U.S. District Court in Buffalo is now mediating release of the data to EPA, Hooker, the home owners, and also to the Center for Disease Control, which plans to begin its health studies sometime this month.

Lois Gibbs, president of the home owners association, believes that the state has withheld the data for three reasons. First, she says, there is a high health risk to residents living in the area. The state knows this, but cannot afford to spend much more than the $35 million it already has spent on remedial cleanup and purchase of 239 homes. Second, if the state acts to relocate permanently all affected Love Canal families, a precedent will be set. With its own recent survey identifying 680 hazardous waste dumps across the state, 68 in Niagara County alone, the state looks askance at this prospect.

And finally, Gibbs claims, the state designed a flawed questionnaire, collected information badly, and interpreted the data poorly.

"If that study were to go out into a scientific forum, it would be ripped apart," she says. It wasn't exactly "ripped apart," but it was recently rejected by *Science* magazine for, in part, not identifying which of the two control groups it used was more appropriate for comparison with the exposed population.

Health studies went into abeyance until May 1980 when a "leaked" story appeared on the television evening news, announcing the unconfirmed results of an uncontrolled "study." The study, conducted for EPA by Dante Picciano, scientific director of Biogenics Inc., a small Houston firm, found broken or extra chromosomal (genetic) material in 11 of 36 residents, which it linked to chemical exposure, and which it said foreshadowed miscarriages, cancers, and other disorders.

Preposterous though it may seem, an attempt was made to gloss this limited, uncontrolled study, undertaken to gather legal evidence for EPA's lawsuit against Hooker, with a scientific sheen by having two expert panels review it. These panels assailed the study for lacking controls and for other methodological deficiencies after reviewing, not primary chromosome preparations, but the report itself and photocopies of photographs of these preparations.

Still a third panel of academicians, reviewing the primary material, supported some of Picciano's findings and called for an expanded, controlled chromosome study of residents.

Paigen selected the 36 residents for the chromosome study, and she tells C&EN that she also had controls picked out, but that she and Picciano were rebuffed by EPA on this issue.

Paigen also was involved in another study that surfaced with the chromosome test. This one, designed and conducted by Stephen Barron, assistant professor of neurology at the State University of New York, Buffalo, charted the conduction of the nervous impulse along peripheral nerves in 35 residents presumably exposed to the neurotoxins found at Love Canal, and in 20 control subjects.

Barron, a neurologist not a statistician, at first thought his data showed a slowing of conduction in exposed residents. At the request of EPA, he submitted his data to rigorous statistical analyses, and in the process "the difference in the mean nerve impulse velocities of residents vs. controls lost power, but the direction of change was still there: a slowing of nerve conduction in Love Canal residents," Barron explained.

The velocity of conduction is a sensitive indicator of neurological damage, appearing long before such overt symptoms as tingling and numbness occur. Nerve conduction, therefore, may be an excellent biological marker for toxic exposure. Barron is encouraged enough by his findings to seek funds for a larger study from EPA and private foundations.

Although Barron's preliminary nerve study was not statistically significant, but nonetheless "meaningful," and Picciano's limited study of chromosomes was widely criticized as no better than a legal fishing expedition, they became the scientific veneer to the federal government's decision to declare—for the second time in two years—a state of emergency at Love Canal. The government had little choice. The incredibly poor manner in which the chromosome data were handled raised the already high level of fear and hysteria still higher. This fear was little quelled by the government's insistence on temporary relocation of the 710 affected families, so chosen because they lived in the tax abatement area created by the state legislature to encourage people to remain in the area.

On May 21, the day the emergency declaration was announced, Gov. Carey called Love Canal a "neighborhood of fear" and said that temporary removal was not sufficient to alleviate "the disruption of their lives and the continued trauma." He called on the federal government to match the state's efforts by purchasing the homes that are now "presumed to be contaminated."

As the tug-of-war between the state and the federal government continues, the parade of health studies marches on. In June, the Environmental Defense Fund, with funding from private foundations, began preliminary tests that will chart growth and maturation of children under 18, and nerve conduction in children and adults. Joseph Highland, head of the environmental group's toxic chemicals program, is spearheading this effort. Paigen is an unpaid consultant on both studies, and Barron will conduct the nerve studies.

The rationale behind both studies is that simple, noninvasive, biological markers of health effects related to toxic chemical exposure exist. Growth and maturation and nerve conduction may be such markers.

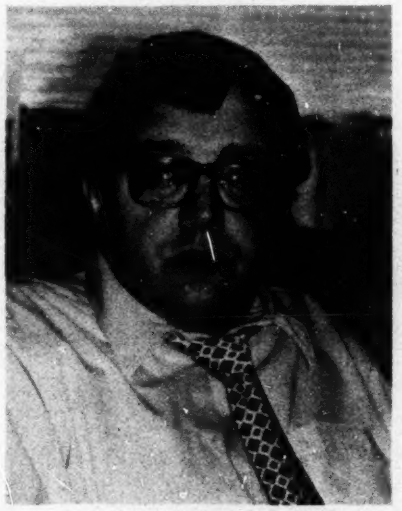
Growth and development are retarded in animals exposed to toxic chemicals; children also may be so affected. The preliminary study, which the scientists feel is adequately controlled, will test this hypothesis. Because it wasn't a government-sponsored study, resident participation, including children who already had moved from the area, was high—about 60 to 70%. The collected growth data are now being analyzed, and the nerve-conduction tests are just getting under way.

Highland has submitted a proposal to EPA for funding to expand the growth and nerve conduction studies. His proposal, though well received, has not yet been funded by the agency. However, he recently received $50,000 from the Frank S. Gannett Newspaper Foundation to support these efforts.

The immediacy of testing and the high rate of participation may give added weight to Highland's preliminary (and now expanded) efforts, especially if CDC's studies are delayed further and permanent relocation begun, which will scatter still more residents and lower the participation rate.

CDC's studies, which were to begin the first week in August, originally were to be conducted by EPA. Sometime between the emergency order of May 21 and early June, the responsibility for health testing shifted to CDC. The order came from the White House, possibly in response to EPA's poor handling of the chromosome study, possibly because the Office of Management & Budget and the Office of Science & Technology Policy believe that "no program to establish an emergency capability in health effects should be developed by EPA," or possibly because New York health commissioner David Axelrod, who, it's said, bears little love for EPA, asked that CDC assume responsibility.

At any rate, three months after the emergency declaration, federal health testing, to be headed by CDC's Clark Heath, has not begun. CDC proposed to begin what it calls its first-level tests—"executive" physical examinations and routine blood tests—on all Love Canal residents Aug. 1. From this larger group, individuals selected at random would be included in the so-called second-level specialized tests, whose results would be compared with two control groups.


LaFalce: fighting since 1977

The second-level tests would scan for toxic effects on chromosomes, nerve conduction, the reproductive system, the immune system, growth and development, and psychological well-being. About 40 subjects for the chromosome study were chosen from 12 families whose homes were the most highly contaminated by chemicals.

According to CDC's Renate Kimbrough, physical examinations were to have been completed by the end of the year, and the specialized tests were to have been completed but not analyzed by December. This schedule has been thrown out of kilter by the residents' boycott. CDC, attempting to balance immediacy against sound methodology, wants to select subjects for its specialized tests. Six community organizations want all residents to participate.

CDC claims that there is not enough money or laboratory resources to test all residents for chromosome damage, to take just one example. Furthermore, Heath claims that though the residents are concerned about their health, their more immediate concerns are "relocation, and economic dislocation and attendant uncertainties." But, he says, "the health studies shouldn't be looked upon as a source of any useful data in the near future for deciding the relocation issue."

Disregarding the relocation issue, Heath admits that chemical toxicology, an embryonic science, places a constraint on the types of studies that now can be devised to show a cause and effect relationship between exposure to toxic chemicals and disease.

Heath says: "It is a difficult problem to say a low-level exposure to this or that chemical, let alone to these chemicals in combination, does or does not cause illness. Most of the chemicals cited at Love Canal appear to be at low levels. We know from traditional acute toxicological principles that these aren't the kinds of levels one would expect to produce outright acute toxicity. But the concerns here deal with unknown and rare effects. That, plus the fact that we are dealing with chemicals acting in combinations that have never been tested, makes it difficult to predict even which effects should be looked for."

CDC's tests, if they are ever begun, are not likely to prove or disprove a causal connection between exposure to chemical contamination and disease among the residents of Love Canal. Because of the time lapse—two years for the families removed from chemical contamination in August 1978—probably the only valid study that now can be conducted, says Paigen, "is a registry of all current and former residents of Love Canal with health followups over the years."

Despite the problems, in 1978 and 1979 the state health department made a considerable effort to "determine the chemical risks faced by the 2618 people who then lived in the Love Canal neighborhood." From its own statistics: It drew 4386 blood samples from 3919 people (some controls) and conducted 114,036 separate blood tests; it conducted 11,138 field interviews with Love Canal and surrounding area residents; it is searching for and conducting health followups on some 2000 people who once lived in the area but moved before 1978; and it conducted 411 physical examinations of workers who performed remedial construction work at the landfill.

From the health and environmental data it has amassed, the state health department concludes that:

- There is an excessive rate of miscarriages and low-birth-weight babies and, possibly, congenital birth defects in certain sections of the Love Canal area, although these cannot be related to chemical exposure.
- There is no evidence for an excess of liver and kidney abnormalities, leukemia, and other blood diseases.
- Cancer rates are within normal limits for this population.
- Computer analysis of the epidemiological survey produces no evidence of "unusual patterns of illness."

In summary, the health department has not been able to correlate the "geographic distributions of adverse pregnancy outcomes" with evidence of chemical exposure. "At present, there is no direct evidence of a cause-effect relationship with chemicals from the canal." The caveat, of course, is that there still might be a cause and effect relationship that has not yet been identified.

Because of the implications to future waste-related environmental health problems, the search for a causal nexus has been intense and continuous. Paralleling its health effects surveys, the state health department has launched a massive environmental monitoring and analysis effort including 5924 soil samples from more than 650 homes and the landfill, of which 2500 have been analyzed, and more than 700 air, sump, and water samples and analyses.

More than 400 separate chemicals have been identified by the state and EPA, including the 2,3,7,8-isomer of dioxin—one of the most potent toxins known to man. This finding was not unexpected. Hooker disposed of trichlorophenol at the canal, and dioxin is the unintentional contaminant of trichlorophenol. But what is alarming is where it was detected: in a composite of surface landfill soil at 5.3 ppb; in a subsurface soil sample taken from the backyard of a 97th St. home abutting the canal at 6.7 ppb; in sediment samples from Black Creek, which flows into the Niagara River, at 30 ppb; and in a composite sample of crayfish taken from Black Creek at 3.1 ppb.

According to health commissioner Axelrod, the state's environmental sampling program confirmed the presence of a "host of toxic chemicals in the landfill"; documented the outward migration of some of these chemicals, "principally through porous topsoil and drainage pipes"; and confirmed "diminishing degrees of soil and air contamination as one moves further away from the landfill." EPA's studies generally confirm the state findings.

The environmental data served, in part, as the basis for the state's August 1978 emergency declaration which, among other things, ordered the Niagara County Board of Health and the city of Niagara Falls to take remedial action to abate the pollution and halt its spread. As a result of this order, the city contracted with the Canadian firm of Conestoga-Rovers & Associates to install a tile drainage system about 40 feet beyond the landfill but paralleling its full length on both sides, and to place a sloping clay cap completely over the landfill.

Hooker disposed of 21,800 tons of chemicals

Type of waste	Estimated tonnage
Miscellaneous acid chlorides	400
Thionyl chloride	500
Miscellaneous chlorinations	1,000
Dodecyl mercaptans (DDM)	2,400
Trichlorophenol (TCP)	200
Benzoyl chloride	800
Metal chlorides	400
Liquid disulfides (LDS/MCT)	700
Hexachlorocyclohexane (BHC, Lindane)	6,900
Chlorobenzenes	2,000
Benzyl chlorides	2,400
Sulfides	2,100
Miscellaneous 10% of above	2,000
TOTAL	**21,800**

The drainage system, completed in December 1979, now collects precipitation runoff and canal leachate, which are delivered to an on-site filtration plant that removes 99% of the toxic organic chemicals. The treated water is discharged to sanitary sewers that flow to the city's water treatment plant. The effectiveness of this remedial action in stemming the lateral outward flow of chemicals from the canal will be determined by EPA if it is permitted to carry out its proposed environmental studies.

According to state geologists who made hundreds of borings around the landfill during the construction of the leachate collection system, the soil strata of the landfill are fairly well defined. From ground level to about 5 feet below grade, the soil is sand and silt—a permeable layer that allows leachate from the canal to pass easily. Below this layer to a depth of about 25 feet are lacustrine clays, which are very impermeable. Below this layer, to a depth of 40 feet, is glacial till, a highly impermeable layer; and below the glacial till is limestone bedrock.

The geologists don't know the exact depth to which the canal was excavated, but seismic surveys over its central and northern portions suggest that the excavation was 12 to 13 feet deep. The excavated depth of the southern section is not known and, therefore, the thickness of the protective clay layer between buried chemicals and bedrock is not known. Hooker did most of its dumping on the southern section of the canal, and the highest levels of contamination and reported illnesses were found in homes abutting this portion.

Still, Frank Rovers of Conestoga-Rovers supports Hooker's contention that the nature of the soils at Love Canal made it an ideal burial vault for chemicals. He asserts that "the hydrogeological environment of Love Canal would allow for adequate design of a secure disposal facility," even under today's more stringent Resource Conservation & Recovery Act regulations. The problems at Love Canal, he says, resulted from a failure to monitor and maintain the site after closure, and from disruption of the closure by subsequent construction.

The courts, of course, will decide who was liable for monitoring and maintenance: Hooker, which no longer owned the land, but which knew the nature of the chemicals it buried there, and had the expertise to monitor and analyze for migrating chemicals; or the board of education and the city of Niagara Falls, which owned the land and developed it, but which might not have fully comprehended the nature of the chemicals disposed by Hooker, nor had the expertise and perhaps even the understanding to acquire outside expertise to monitor the site. Or the courts may find all liable.

Hooker claims that it placed a clay cover over the northern and southern ends of the landfill (it never used the central portion for dumping) when it closed it, and that disruption of this cover by road building, other construction, and removal of the dirt itself broke the integrity of its closure. In its lawsuit against Hooker, the Justice Department claims that the company "did not place an adequate clay cap or other appropriate seal on the canal."

No public documents have yet surfaced to support Hooker's claim of a clay cover, although Hooker may have such documents, which it will bring out in court. However, Frank Ventry, an operating engineer for the city of Niagara Falls who worked at the landfill site after Hooker deeded it to the school board, tells C&EN that it was the city that covered to grade the full length of the canal, including the two ends that Hooker claims to have covered. He says this was done mostly by backfilling from the mounds of dirt piled on the banks of the canal from the original excavation. This point will be argued in court because it bears on the question of whether Hooker properly secured the landfill before it turned it over to the school board.

Although the canal has been deemed an exceptionally fit site for hazardous waste disposal by Hooker and Rovers, there are some natural geologic formations such as swales—dried up streambeds—and a sand lens—a thin layer of sand interspersed between more impervious clay layers—that may have served as preferential routes of migration for the chemicals.

It is not reasonable to assume that Hooker or any company dumping in a landfill in the 1940's and 1950's would have been aware of such geologic formations, but it might be reasonable to assume that diligent, continuous monitoring would have picked up wayward chemical migrations via these formations. The courts will consider the monitoring issue, especially who can be held liable for the lack of monitoring.

Certainly, one of the major routes of chemical migration was, to use Hooker's analogy, the overfilled bathtub. That is, the rising water table in the clay bathtub carried leachate upward and laterally outward through the more permeable top 5 feet of soil.

Gibbs: leading the home owners

But there were two other manmade conduits, according to the Love Canal Homeowners Association consultant, Stephen Lester, that were unearthed during remedial construction in 1978–79. One was a French drain, put in by the school board, that completely encircled the 99th St. school. The drain funneled water and chemical leachate away from the school to storm sewers on 99th St. whose contents flow to the Niagara River, south of the canal. Another was an illegal catch basin put in by a home owner on 97th St. that carried water and leachate to storm sewers on 97th St. whose contents eventually end up in Black Creek, north of the canal. An internal EPA memorandum notes that chemicals buried at Love Canal, including dioxin, have been found in the sediments and water of Black Creek and the Niagara River. The storm sewers may be how the chemicals got to the creek.

Whether chemicals have migrated vertically downward through bedrock to underground aquifers has not yet been established. The state Department of Environmental Conservation sunk three wells to bedrock around the canal, sampled from these twice, and found no organic chemical contamination of the water. But the number of wells is too small to be able to rule out contamination. Therefore, the agency is now sinking seven to 10 additional wells around the canal, and EPA—if it is permitted—will sink from 100 to 200 monitoring wells in a grid pattern around the canal and throughout the community.

Some of EPA's wells will go to bedrock to monitor for aquifer contamination and to determine the hydraulic flow in the area. As planned, the wells will determine the efficacy of the remedial construction effort and map the present flow of chemicals through the community. Knowing the hydraulic flow pattern will be important in closing the gap in the federal government's argument that chemicals buried in the canal have contaminated Black Creek, which flows into the Niagara River.

The state environmental efforts essentially have wound down, although efforts such as groundwater sampling from deep wells will continue. So also will Stephen Kim's efforts to analyze for the first time the 6000 soil samples collected a year ago, and to reanalyze blood samples taken in 1978 and 1979.

This month, a major environmental monitoring effort will be launched by EPA if the residents permit it. The effort will include collection and analyses of a massive amount of indoor and ambient air samples, soil, groundwater, surface water and sediments, drinking water, and sump water samples. EPA's Thomas Hauser is overseeing the $5.4 million integrated assessment project, which is being managed at Love Canal by GCA Corp. of Bedford, Mass. The effort is expected to be completed in six months, at which time EPA will be able to estimate the risk to residents of living near the landfill. In six months, however, that estimate may be moot. By then a political decision already may have been made to move the residents out.

The Love Canal incident has always been a saga played out in the political rather than the scientific arena. Even its explosive inception was not ignited by adequate science, Hooker's president Donald L. Baeder says. According to Baeder, it was then-health commissioner Robert P. Whalen's Aug. 2, 1978, declaration of a state of emergency at Love Canal that "created a spark and a fear in these people that blew up to be the Love Canal that we now know today."

A temporary evacuation order was directed only to those families with pregnant women or children under two living on 97th or 99th Streets—slightly more than 20 families. However, several days later, Gov. Carey expanded the evacuation to include all families living on those two streets, and he made the move permanent by pledging to purchase their homes.

At that time the state had health questionnaires that focused on pregnancy outcomes, analyses of soil samples taken from the canal itself, and analyses of basement air samples

EPA accumulates environmental data for lawsuit against Hooker

Source	Data collected	Chemicals detected	Comment
Water from storm sewers at three locations	August 1978	Hexachlorocyclohexane (1.4–50 ppb), trichlorophenol (0.1–11.3 ppb), chlorobenzene (0.3–0.4 ppb), tetrachlorobenzene (18–130 ppb), & others	Exceed EPA's water quality criteria for human exposure
Sediment samples from 10 locations in Black Creek, Bergholtz Creek, Cayuga Creek, Little River, Niagara River	Sept. 1978	Benzene (0.1–1.7 ppb), hexachlorocyclohexane (31–1200 ppb), trichlorophenols (0.5–90 ppb), chlorobenzene (0.4–2.9 ppb), tetrachlorobenzene (24–240 ppb)	Exceed EPA's water quality criteria for human exposure. Chemicals also found upstream but at substantially lower levels
Drinking water from home taps	Sept. 1978	Chloroform (25 ppb), bromodichloromethane (6 ppb), tetrachlorobenzene (2 ppb)	No concurrent sampling done at drinking water plant, so precise source of chemicals not determined; may have resulted from water treatment
Ambient & basement air	Sept. 1978	Benzene, tetrachloroethylene, trichloroethylene, dichlorobenzene in the moderate-ppb range	The incremental cancer risk was calculated as 1 in 100 to 1 in 1000 for some of the homes tested
Leachate from leachate collection system (southern section)	June 1979	Lindane (γBHC) (160 ppb), dichlorobenzenes (7200 ppb), & others	
Leachate from French drain system around 99th St. School	June 1979	Lindane and dichlorobenzenes & others at one-tenth concentration of the same chemicals found in landfill leachate system	
Surface water & home sump pumps (northern section)	June 1979	Phenol (0.4–4.7 ppb), pentachlorophenol (54–70 ppb), trifluoro *m*-cresol (12–102 ppb), [trichlorobenzene (1030 ppb), hexachlorobenzene (250 ppb) found in sumps only]	Exceed water quality criteria for human exposure
Ambient & basement air	Nov. 1979	Light to moderate contamination of a number of chemicals, including benzene	Only 2 homes sampled; location not listed; 1 in 10,000 additional risk of cancer

of the homes bordering the canal collected by EPA and the state. All told, the state found some 82 compounds in the soil, and seven compounds in the air that induce cancer in animals, including benzene, which is a known human carcinogen. From the epidemiologic survey, the state found a 1.5 times greater than expected normal risk for spontaneous abortion. These findings led to the emergency declaration, which Baeder contends was based on "inadequate and incomplete studies."

For instance, Baeder argues, "the concentration of chemicals that were detected in the basements . . . were not compared with any controls, nor were they compared with . . . Occupational Safety & Health Administration standards on allowable limits for these chemicals in a continuous working environment." Nothing was done by Whalen, Baeder says, "to try to put these into perspective as to the levels of exposure, and the risk associated with those levels." Furthermore, Whalen failed to have the epidemiologic data reviewed by competent, independent experts.

The levels of chemicals measured in the basements of the homes, Baeder says, were in many cases "a small fraction of a per cent of what OSHA would permit for a continuous working environment. So if you want our position on the relative risk of exposure to chemicals found, it would be extremely small." Baeder goes as far as to say that the "level of exposure from all of the measurements that have been made at Love Canal precludes these chemicals at the detected level from having an effect on the health of those people. Now, that does not mean that those people aren't suffering from asthma, cancer, leukemia, any other abnormalities they claim. But what the state says is that those disease rates are normal for that population."

But the state, in the person of Stephen Kim, the scientist who analyzed those 1978 samples and who is now director of the state's Toxicology Institute, says: "The primary motivation for Whalen's action was the contamination on the surface of the landfill," to which the residents had open access, not the indoor air samples. "The highest risk was the kind of exposure—body burden—that a child might get playing on the surface of the canal, then eating without washing his or her hands."

Further, Kim says, the state had solid and very compelling evidence for Whalen's order, environmental and epidemiologic evidence that was reviewed by a blue-ribbon panel of government, industry, and academic scientists.

Addressing the indoor air levels, Kim says that OSHA standards—those that the agency has in the form of threshold limit values—are inappropriate guidelines for indoor household air levels, because they are set for a healthy working population, generally male, exposed for only a part of a 24-hour day, five days a week, with a two-day respite of nonexposure. "It's not continuous exposure," Kim argues, "so we don't think it's necessarily appropriate for protecting susceptible segments of the population—the very elderly, sick people, the fetus, and developing children," who may be exposed on a more continuous basis in the home.

In addition, the homes that were contaminated with chemicals usually contained a mixture of compounds that could act in an antagonistic fashion or in a synergistic manner. If the action was synergistic, and no one knows that it was, induced health effects would be greatly enhanced, notes EPA's Hauser.

In short, Kim answers Baeder's charges by saying that internal and external controls were available to him, cancer risk assessments were calculated and have been made public, and the epidemiologic findings as well as the environmental data were reviewed by outside experts before Whalen made his announcement.

The variation of the data, which correspond to certain geologic features, acted as internal controls. External controls included some data from basements in downtown Niagara Falls and the investigators' own homes in Albany, N.Y. Kim also says he attempted to eliminate confounding variables such as chemicals found in consumer products and auto exhaust fumes by using marker chemicals such as chlorotoluene and chlorobenzene, not found in consumer products. These latter chemicals were found in some of the homes and therefore could be expected to have emanated from chemicals buried in the canal, not from normal consumer products.

Still Baeder insists: "The facts are, and the state has so stated, that there is really no evidence to connect the chemicals of Love Canal with the ill effects that are reported by the residents. No information on that." Kim agrees in part. "Of the chemical indicators that we have measured so far," he says, "there is not a statistically significant correlation between those and the health effects that we have studied so far. But that does not mean that such a relationship will not be found, it only means we haven't found it yet.

"Love Canal is an important landmark in environmental health; finding a cause and effect relationship in this type of situation has never been done before. But our effort is continuing intensively," Kim says.

There is no question that society is on a learning curve with respect to environmental health issues. There also is no question that chemical-analytical probes are more advanced than medical probes. But all that is moot.

Love Canal, because of an incredible series of events, has moved beyond the scientific pale: Decisions affecting people's lives and corporate actions are being based on political expediency and liability law. However, if the Love Canal saga is allowed to play out, it may extend the frontiers of corporate responsibility as well as those of law and environmental health science.

At the moment, Hooker has chosen to follow a more legalistic path. Other companies might have responded differently. But the problem a corporation faces today, says Robert Roland, president of the Chemical Manufacturers Association, is "when and under what circumstances does [it] respond to the equities of a situation vs. the legalities of a situation. When does the equity concern of what you think is the correct thing to do take precedence over the legal concern?" It's a difficult balancing act to maintain, Roland admits. And there's no denying that on the question of equity, "there has been a definite change in mindset" in the past few years, Roland says.

He elaborates: "A decision made in 1980 would by necessity be different from a decision that was made in 1975. I think that enough has happened during that period to alter the response that a company would give to a Love Canal-type situation. The legal concerns—personal liability, environmental damage, all of the rest—are no less grave today than they were then, but the recognition of the terribly adverse impact that the media can have, that inappropriate governmental response can have, that human expectations can have on such a problem, demand a response that may be less legalistic and more humanistic."

Hooker essentially took a legalistic stance. Baeder says, "I believe that the company was very responsible in the way it handled those chemicals, in the closing of the canal, in the transference to the city for the use intended, and in warnings to the school board when we were appraised of situations [proposed land development]."

The federal government and the state of New York apparently disagree. The Justice Department in December 1979 filed a $45 million suit against Hooker for waste disposal at Love Canal, part of a $124.5 million suit against the company for hazardous waste disposal at four dump sites in Niagara Falls. New York state in April 1980 filed a $635 million suit against Hooker. Both suits seek damages for the consequences of the dumping of hazardous wastes at Love Canal. Hooker has answered only the federal complaint, denying liability.

Should the federal claim go to trial, two prime issues will be litigated: adequate warning and ultrahazardous activity. The concept of ultrahazardous activity is well established, but not for cases involving the disposal of toxic materials. If the court deems the disposal of toxic wastes an ultrahazardous activity and imposes the excessive duty of care and responsibility on Hooker that has been established for other activities deemed ultrahazardous, then the limits of liability law will have been enlarged.

The federal complaint states that Hooker did not give adequate warning. Barry Trilling, the Justice lawyer handling the case, says: "Hooker had knowledge of what was in the site, it had better knowledge than anybody about the dangers and hazards of the chemicals; it had the scientific capacity to know what may or may not happen; and it was in the best position to let people know what the problems were."

That succinct statement may be the government's strongest argument in its suit against Hooker. There is now a flurry of activity at EPA and Justice to gather the preponderance of evidence needed to establish the government's claim.

Whether Hooker chooses, in Trilling's words, to test "the fires of adversary litigation," or settle the suits out of court—which some believe it will do to avoid further adverse publicity attendant to the discovery of evidence during a trial—is a litigation management problem that Hooker will have to resolve.

Certainly, adverse publicity already has hurt the company, even in actions that it has taken that are environmentally "acceptable." For example, this fall, Hooker will begin operating a $94 million energy-from-waste project at its Niagara Falls plant. The project's financing took five years, and the private underwriters admit that the Love Canal incident probably added a half point to the financing cost.

The harsh glare of adverse publicity also has fallen on governmental response to the challenges of Love Canal. Bureaucratic bungling, interagency haggling, and bows to political expediency that in part have characterized this response have been spotlighted in the press.

Before the most severely exposed residents moved away and before remedial measures were taken to stem the tide of migrating chemicals, well-designed and -executed monitoring studies might have served as the basis for sound policy decisions on future Love Canal-type incidents. But the passage of time makes a cause and effect relationship more difficult to discern. The body heals and the environment cleanses itself.

Now the best that can be salvaged from the planned federal effort is the beginning of a record chronicling the possible health effects on residents exposed to long-term, low levels of a mixture of toxic chemicals. The proposed studies cannot and will not satisfy the residents' desire to know their future health prospects, or those of their children. The studies cannot and will not tell women whether they can bear healthy children. Nor will the studies yield enough information on which decision makers can set good public policy in the near future. But they will be a beginning.

The pity of Love Canal is that so many lives have been so badly disrupted, and an unfortunate but exceptional opportunity to expand our knowledge of chemical toxicity has been frittered away. □

Chemical & Engineering NEWS

Analytical successes beget new demands
A C&EN Science Update Page 30

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Big-volume acids

Profit hopes rest on phosphate exports

A Key Chemicals Review *Page 12*

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Cover: Sulfuric acid unit at Freeport Minerals' phosphoric acid complex at Uncle Sam, La.

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News of the Week

- ***Stocks of leading chemical companies*** *are keeping up with the general market advance; the price index is up 26% from the March figure.* ***Page 6***
- ***OSHA publishes list*** *of 198 substances that warrant further scientific review as potential workplace carcinogens.* ***Page 7***
- ***Las Vegas remains the site*** *of the upcoming chemical congress even though the strike in San Francisco has been settled.* ***Page 7***
- ***Recombinant DNA lab at UCSD*** *plagued by cloning of wrong mosquito virus and theft of rabies virus.* ***Page 7***
- ***NSF report consolidates data*** *on employment of scientists and engineers with information on R&D spending.* ***Page 8***
- ***EPA will study captan,*** *widely used fungicide for fruits, vegetables, and seeds, to see if it poses cancer risk.* ***Page 8***

Business

- ***Output of big-volume acids****—phosphoric and sulfuric—remains high because of booming phosphate exports.* ***Page 12***
- ***Du Pont economist*** *reassesses questions on U.S. recession, now sees recovery beginning earlier and moving faster.* ***Page 15***

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- ***NSF's chemistry division*** *draws good marks for dispensation of grant money and praise from admiring chemists.* ***Page 19***

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- ***Signal hypothesis,*** *which explains how proteins are transported across membranes of living cells, is challenged by researchers at MIT and Institut Pasteur.* ***Page 26***
- ***Jojoba plant*** *that bears flowers containing both male and female parts has important economic potential.* ***Page 28***

Science Update

- ***Analytical chemistry,*** *called upon for more detailed information, responds by combining techniques, inventing new ones, adapting lasers and computers for its use.* ***Page 30***

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- ***Chemical industry's good record*** *in energy conservation can be improved even further with more sophisticated R&D.* ***Page 35***
- ***Montedison renames research center*** *in Ferrara, Italy, for the late polymer scientist and Nobelist Giulio Natta.* ***Page 35***
- ***Two prototype gasification plants*** *using the Shell-Koppers process will be built in the Netherlands and West Germany.* ***Page 36***

ACS News

- ***ACS should set up an economic status task force,*** *executive committee of California Section resolves.* ***Page 40***

Exports underpin high acids production

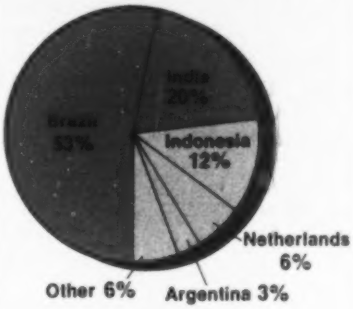
Despite slowed market for phosphates in U.S., resurging exports demand is shielding phosphoric and sulfuric acids from recession so far

These days, exports of phosphoric acid and its derivatives are everything. Producers of phosphoric acid and supporting producers of sulfuric acid would be in considerable difficulty without the current export boom.

In 1980, exports of one kind or another of phosphorus-containing compounds will account for a third of all U.S. production of phosphoric acid, which, in turn, takes about two thirds of sulfuric acid produced in the U.S. Specifically, phosphate exports this year will total about 3.9 million tons (in terms of P_2O_5, the common measure) out of a total 10.3 million tons of P_2O_5 as phosphoric acid.

To a large extent, this unusually high level of exports results from a lackluster spring fertilizer season in the U.S. Without the surge in exports, U.S. production of phosphoric acid in 1980 would be off by a significant amount, possibly 10%.

Most U.S. phosphoric acid exports go to Brazil, India



Jan-Apr 1980 P_2O_5 exports = 205 million tons

Note: Fertilizer-grade phosphoric acid only, excluding superphosphoric acid to the Soviet Union. **Source:** Commerce Department

Exports of all kinds of phosphate materials are expected to be up 15% at least (in terms of P_2O_5) over exports in 1979 of a little more than 3 million tons. Some in the industry say that exports could be even higher if material were available.

The importance of exports of phosphate materials to the chemical industry is becoming recognized outside this industry segment. In 1980 the value of these materials—acid and derivatives—will exceed \$1 billion out of total exports of a bit more than \$20 billion for all chemicals and allied products. Ten years ago, the phosphoric acid export business scarcely existed, and derivative phosphate exports were worth about a tenth of their present value.

Although fast-rising demand for phosphate materials throughout the world is spurring growth in U.S. exports, price remains important. Earlier this year, phosphoric and sulfuric acid producers were expecting a strong U.S. market for phosphate fertilizers (C&EN, Feb. 25, page 10). Prices of some materials such as DAP rose 30% to about \$260 per ton.

At this price, the major foreign buyers of DAP held off and watched for actual sales prices during the big spring market in the U.S. When U.S. farmers cut their buying and dealers didn't order, producers slowed plant operations and cut prices. Then foreign buyers jumped in.

Depending on weather conditions in major foreign consuming areas of phosphate materials, part of the increased exports of phosphate could go into inventory. Hence, some producers suggest that 1981 could see only minor growth, if any, in exports. Overbought foreign phosphates have been a problem in the past.

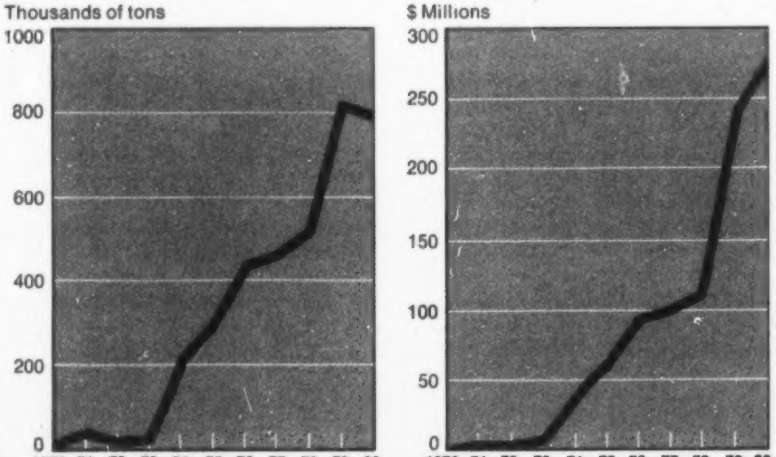
Longer term, most phosphate producers expect the foreign business growth to continue. Many U.S. producers are putting money on this expectation by planning large increases in phosphoric acid plant capacity. Even bigger capacity increases are due in basic phosphate rock mining capacity.

As yet, no big warning flags have gone up over the rash of actual or proposed expansions in phosphoric acid. Perhaps the current high rate of return on phosphate chemicals has dimmed the memory of the difficult times for the phosphate industry caused by overbuilding in the mid-1970's. Another difficult period might occur just a decade later in the mid-1980's, some observers fear, especially if potentially large foreign phosphate developments finally get moving.

For details of the immediate outlook for sulfuric and phosphoric acids, see the following pages.

Bruce Greek, Houston

Phosphoric acid exports have risen dramatically



Sources: Commerce Department, industry, and C&EN estimates

Key Chemicals

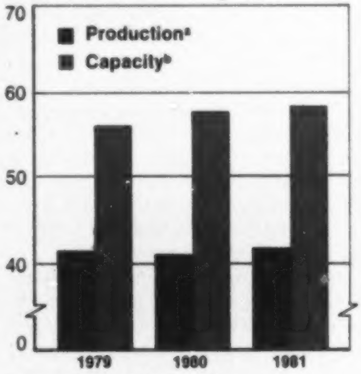
Sulfuric acid

H_2SO_4

- ***Demand stalled***
- ***Capacity rising***
- ***Prices rising***

PRODUCTION

Millions of tons, 100% H_2SO_4



a From all sources. b First quarter.

HOW MADE

Elemental sulfur burned to dioxide, catalytically oxidized to trioxide, and reacted with water; sulfur dioxide from smelter or other sources oxidized similarly and converted to acid

MAJOR END USES

Fertilizers 65%, chemical manufacture, metals and ores refining, and petroleum refining, each 5%

FOREIGN TRADE

Exports—small, under 100,000 tons a year, imports—small, under 500,000 tons a year

PRICES

Posted contract prices for 100% H_2SO_4 $75 to $85 a ton

COMMERCIAL VALUE

$3.25 billion for total production, 1980

At this time, plant location means much in how well sulfuric acid is doing. At some places, U.S. plants are being operated at low levels or not at all, as in the case of copper smelters shut down because of the copper strike. At other sites, particularly south Florida, sulfuric acid plants are operating at maximum levels, even more than nameplate capacity.

This range of operating levels results from the current state of the U.S. economy. In general, industrial uses of sulfuric acid are well down because of the recession. Fertilizer use, roughly two thirds of the total, is strong—largely because of strong export demand for derivative phosphate fertilizer.

Earlier this year, overall fertilizer use of sulfuric acid slumped as inventories of finished fertilizers increased and export buyers waited for lower prices. Once lower quotes on phosphates showed up this spring, foreign orders jumped, although the spring season in the U.S. was disappointing.

Although overall fertilizer use of sulfuric acid has resurged since mid-May, industrial uses remain at low levels. As a result, total production of sulfuric acid during 1980 will do well to match 1979 production of about 41 million tons (in terms of 100% H_2SO_4).

Reduced industrial demand could continue throughout 1980. This plus reduced output of smelter acid could drag total sulfuric production in 1980 a bit below that of 1979, even with a small gain in consumption of sulfuric in making phosphate fertilizers.

The outlook for 1981 production remains almost as scrambled. Factors influencing future sulfuric acid output range from the shape of the economic recovery to the state of oncoming production capacity in other parts of the world. Other factors include current fertilizer inventory building, both in the U.S. and foreign countries; pricing strategies; and shipping facilities.

Most producers expect industrial uses of sulfuric acid to increase somewhat during the third and fourth quarters of 1980 although it will fall quite short of first-quarter 1980 levels. With almost half of the third quarter now gone, industrial demand remains sluggish, so hopes are fading for improvement this quarter.

If industrial applications do come up to past levels, and fertilizer use posts its expected 3% gain for 1981, production of sulfuric acid in 1981 will exceed 1980 2% or so to reach a total of 41.8 million tons.

Such growth also assumes that scheduled expansions of plant capacity over the next year are on time and that smelter acid production about equals 1980 levels. Total sulfuric acid capacity is expected to climb half a million tons during 1980 to reach 58 million tons in first-quarter 1981.

Exports of phosphate fertilizers could be the real key to 1981 sulfuric acid production. Very strong now, these exports still depend on the amount of competition from local and imported phosphates in countries where U.S.-produced phosphates are now being shipped.

The optimists among U.S. fertilizer industry sources say that fast-rising demand for phosphate fertilizers throughout the world not only will take care of new capacity in other countries but will improve operation of existing capacity. Pessimists look at the heavy slate of U.S. and potential foreign phosphate expansions in 1982 and 1983 with some alarm, although not for 1981.

Competition from foreign producers could stiffen further if they get reliable supplies of sulfur to make the necessary sulfuric acid for their phosphate operations and especially if the country has substantial supplies of phosphate rock. Morocco is the most important such candidate, but it has had long-standing political and technical problems in realizing its potential. No resolution is in sight.

Sulfur recovered from natural gas associated with oil production in the Middle East will become available as raw material for sulfuric acid, but some sources think that the rising demand for phosphates could take up all this sulfur and more. For the near term, a drawdown of existing sulfur supplies appears the main way for new and old producers worldwide to make enough acid to meet demand for phosphate fertilizers. This could keep rising cost pressure on sulfuric and phosphate producers and make strong export demand even more important.

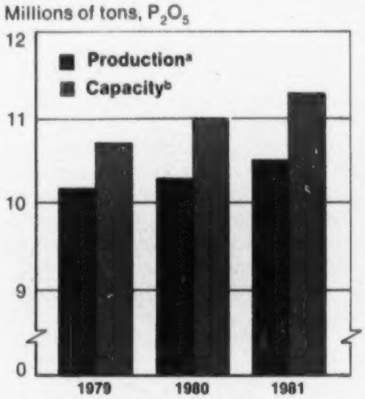
Key Chemicals

Phosphoric acid

H_3PO_4

- ***Export demand big***
- ***Capacity up a bit***
- ***Prices to rise***

PRODUCTION



a Both wet process and furnace acid.
b First quarter.

HOW MADE

Reaction of phosphate rock and sulfuric acid; burning of elemental phosphorus and subsequent reaction with water

MAJOR DERIVATIVES

Ammonium phosphates 60%, triple superphosphates 20%

MAJOR END USES

Fertilizer 85%, detergents 5%, animal feeds 5%

FOREIGN TRADE

Exports—could exceed 800,000 tons of P_2O_5, imports—very small

PRICES

\$350 per ton (100% P_2O_5) for fertilizer

COMMERCIAL VALUE

\$3.6 billion for total production, 1980

Phosphoric acid producers are going full tilt, despite a dip in the U.S. market for downstream phosphate fertilizer. The reason is a rush this summer by foreign phosphate buyers.

Currently, most wet-process phosphoric acid plants are being run at or above nameplate capacity. Production is expected to remain high during the rest of 1980 but probably down somewhat from the present superheated levels.

Early in 1980, phosphoric acid production was running all out (C&EN, Feb. 25, page 12). Then came a slump in demand, especially in the U.S., during the spring months. Producers realized that dealer inventories were indeed high and that foreign buyers would not pay the exalted prices that had been reached for phosphate derivatives.

Producers reacted by shutting down plants for maintenance. At the same time, prices dropped for export fertilizer, and dealers sold their inventories more than expected. As a result, inventories began to disappear in mid-May.

More attractively priced exports of phosphate fertilizers surged in June and continued strong in July, further pulling down inventories at producers' plants. Some of these inventories were being held against an anticipated repeat of last fall's early buying spree by U.S. phosphate customers.

So the word went out at phosphoric acid producers to hurry the maintenance and get the plants running again. Since many plants were then in better shape, production jumped strongly and is expected to continue at this pace long enough to put 1980 production of phosphoric acid slightly over 1979 production. The gain will be perhaps 1% to 10.3 million tons (in terms of P_2O_5) from 10.2 million tons in 1979.

The gain in production will come entirely in wet-process acid, the type used in fertilizer. Furnace-acid production probably will continue its slow decline, which will require wet-process acid to increase more than the 1 to 2% gain forecast for total production.

The growth in phosphoric acid production may continue through 1981 under the same propulsion. Total production next year could be up again 2% or so, with the gain again coming entirely in wet-process acid. Since the U.S. market has been soft, gains in production now and next year depend mainly on international demand.

All but a small quantity of phosphate fertilizers are based on phosphoric acid, which is made by reacting phosphate rock of varying quality with sulfuric acid. Long-term growth for phosphoric acid seems assured, especially now that more and more raw-material sulfur for sulfuric acid is becoming available as by-product from oil and gas production and from sulfur dioxide cleanup in industrial and utility smokestacks.

Phosphoric acid producers sense this, too, and have committed a lot of new investment for capacity to come on stream in two to three years. This year, U.S. capacity for phosphoric acid will grow very little, no more than 3% based on expansion announcements.

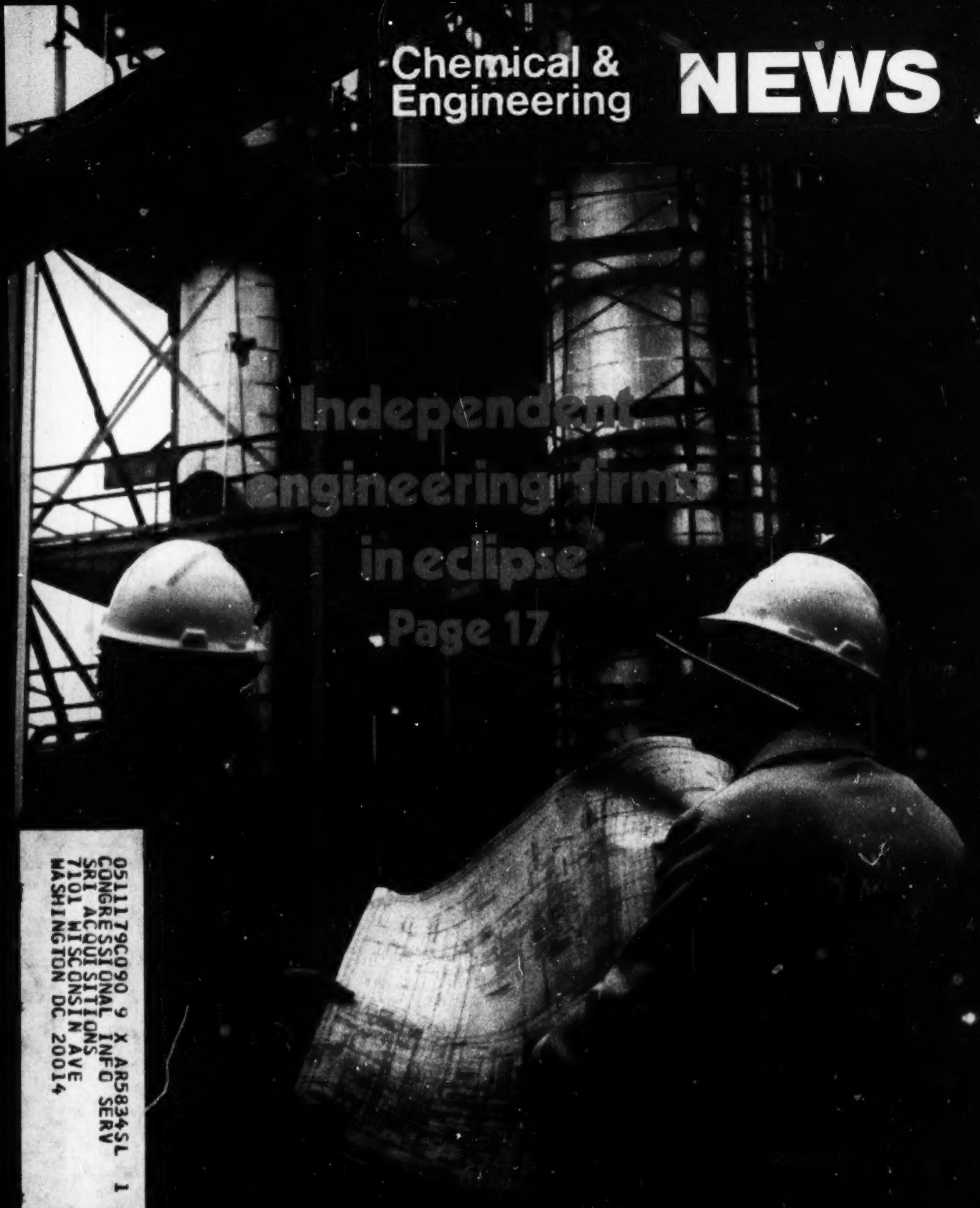
However, most new plants are overdesigned by varying amounts depending on the kind of equipment, management philosophies, and expectations of quality of rock to be used. Thus an accurate figure for capacity is elusive.

A clue to the overcapacity of wet-process phosphoric acid plants comes from comparison of production and capacity. If furnace-acid capacity of about 1.4 million tons (of P_2O_5) is taken out of the total, about 9.5 million tons of capacity remains as wet-process. Similarly, if 1980 furnace-acid production of about 700,000 tons is deleted from the total, wet-acid production would appear to be about 9.6 million tons (of P_2O_5).

On the basis of this calculation, which excludes production from new capacity added during the year, the wet-process acid plants are operating at an average of 101% of nameplate capacity. This makes no allowance for maintenance time, even though some plants were down more than two weeks in late spring. Hence, skillful phosphoric acid plant operators may be able to coax 10% more than top-rated production out of their units for substantial parts of the year.

However, continued good business in phosphoric acid is not guaranteed. The spring slump in U.S. phosphates could be a warning about U.S. demand, and the summer bulge in foreign buying will need watching lest it turn out to be a one-time effect of a temporary price fluctuation.

Chemical & Engineering NEWS



Independent engineering firms in eclipse

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News of the Week

- ***American Petroleum Institute report*** *is optimistic that the U.S. can develop independent energy resources by 1990.* ***Page 10***
- ***Recombinant DNA technology firm Genentech*** *plans to go public.* ***Page 10***
- ***Nitrites will not be banned from foods;*** *FDA and USDA cite insufficient evidence that the compounds are carcinogens.* ***Page 11***
- ***Process to make glass rodstock*** *for optical fibers, in worldwide use, earns patent for Bell Labs scientists.* ***Page 11***
- ***CMA proposes model legislation*** *for siting hazardous waste dumps in which citizens of states would participate.* ***Page 11***
- ***Labor Department's standard for lead*** *in the workplace upheld by appeals court after industry, union challenges.* ***Page 12***
- ***Robert A. Neal*** *becomes the next president of the Chemical Industry Institute of Toxicology Feb. 1, 1981.* ***Page 12***

Business

- ***Engineering-construction firms*** *find 1980 slow, blame foreign business downturn and chemical industry spending cuts.* ***Page 17***
- ***Rosy future forecast*** *for new linear LDPE; swift rise stimulated by better properties for applications and lower cost.* ***Page 21***

Government

- ***OSHA issues potential carcinogen list,*** *will choose chemicals to be regulated first under new cancer policy.* ***Page 23***
- ***Third annual report*** *of task force on environmental cancer and heart and lung disease inventories research.* ***Page 24***
- ***Chlordane sparks controversy:*** *GAO and Velsicol differ on risks.* ***Page 25***
- ***"Regulatory Reporter"*** *evidence of effort by federal agencies to coordinate regulation of chemicals.* ***Page 25***

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- ***Mt. St. Helens eruptions*** *give scientists opportunity to study gases, particulate matter dispersed by volcanic activity.* ***Page 28***
- ***New method analyzes bonds*** *and bond angles on materials surfaces.* ***Page 32***

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- ***Superalloys can be cast*** *with process engineered by GE.* ***Page 33***
- ***Thin-film solar cell*** *with efficiency of 9.4% developed by Boeing.* ***Page 34***
- ***Alkyl phosphate zirconium salts*** *show promise as support materials for reverse-phase liquid chromatography.* ***Page 35***

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- ***"Nuclear Power: Technology on Trial"*** *focuses on technological issues although social aspects may be more critical.* ***Page 37***

Awards

- ***ACS announces the 1981 winners*** *of the society's national awards.* ***Page 40***

Engineering firms in midst of slow 1980

Blame laid to downturn in foreign business and cuts in capital spending by chemical industry; synfuels projects hold key to future growth

Engineering-construction firms, like many U.S. industries, this summer are in the doldrums. However, these firms have been resting there for some time now in terms of projects, if not in overall profits.

There is much to blame—a turndown in overseas business, lack of new projects in the chemical process industries, and restraint on the part of chemical companies to commit funds to new capital projects.

Combined sales for three of the top engineering companies—Fluor, Foster Wheeler, and Combustion Engineering—increased 20% to $2.3 billion in the second quarter from the same period last year. This figure, however, includes equipment sales and other nonengineering businesses.

At the same time, combined profits for the three companies increased 35% to $78 million. From the second quarter of 1978 to the second quarter of 1980, they increased 27%.

However, these profit figures are heavily influenced by nonchemical plant projects, such as Fluor's vast oil-field work in Saudi Arabia. The real state of chemical engineering and construction is reflected only in informal comment from company officials. One of the few official hints of softening came in a warning from Halliburton in May that its engineering-construction business, which includes the important chemical plant business of Brown & Root, probably would show lower profits in 1980 than in 1979.

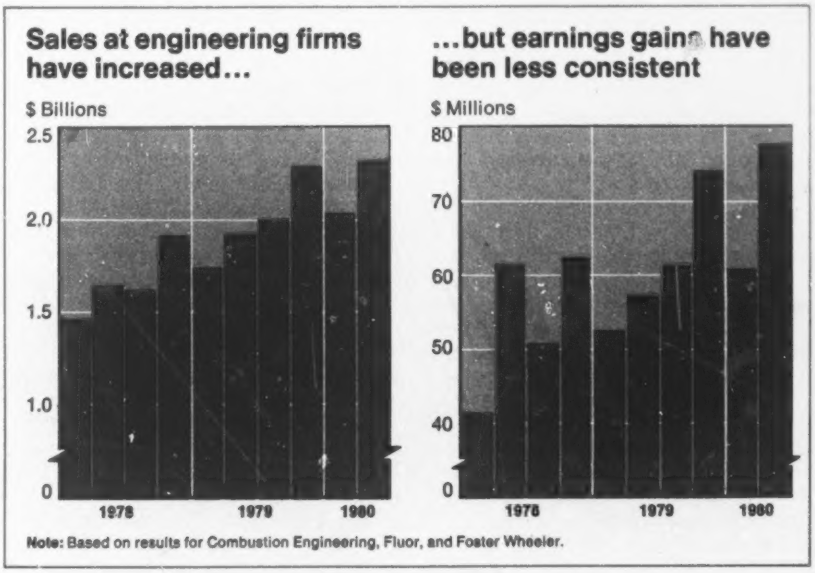
Combustion Engineering in its second-quarter report states: "During the first half of 1980, operating results from design, engineering, and construction services for chemical and petrochemical processing plants declined from the same period in the prior year due to delays in booking new orders and weak market conditions during 1979."

Engineering companies would have been much worse off had it not been for refinery projects. A spokesman for one company says that much of the business in the past two years has been upgrading oil refineries to handle heavier crude oils, get higher quality product out of each barrel of crude, or save energy.

However, even in the oil industry, as in chemicals, engineering firms say that most of their work lately has been upgrading existing facilities. There is no great need right now for an increase in refining capacity.

Also working against the engineering companies has been the trend for chemical companies to do at least part, if not all, of their own engineering on new projects.

The rest of 1980 doesn't look very good for engineering-construction companies. Du Pont in its quarterly economic forecast says that real


Sales at engineering firms have increased...

...but earnings gains have been less consistent

Note: Based on results for Combustion Engineering, Fluor, and Foster Wheeler.

Engineering firms' clients could spend more

It's not that engineering companies' big clients in the U.S. chemical industry couldn't let out more contracts. They easily could and they have set aside considerably increased funds for potential projects. But to date, spending rates have trailed appropriation rates, and unspent funds are rising.

Raw capital spending figures in chemicals and allied products in the U.S. are certainly up, according to surveys by C&EN and a number of other sources. One of these, the Conference Board, a business research group in New York City, measures not only current-dollar spending but constant-dollar spending and similar levels of capital appropriations and backlogs.

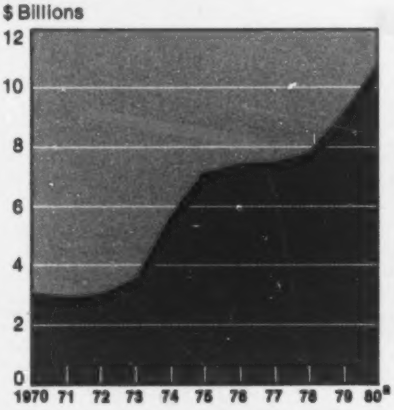
The Conference Board finds a 19% spending increase for the chemical industry in 1979 over 1978, followed by a 26% spending jump in first-quarter 1980 over first-quarter 1979. However, with inflation taken out, these figures fall to 9% and 18%, respectively. And the industry's backlog of unspent appropriations was up 21% in first-quarter 1980 (11% in constant dollars) from first-quarter 1979 after stagnating for the previous four years.

Historically, the rise in backlogs can mean two things—a temporary glut of unspent funds in a capital spending boom (as in 1973 and 1974) or a pileup of money due to project restraint in times of excess plant capacity (as in 1969 and 1970). By all indications, the latter case applies now. Capital spending as a percentage of chemical company sales is at a low ebb at present, and the current recession has brought plenty of excess plant capacity.

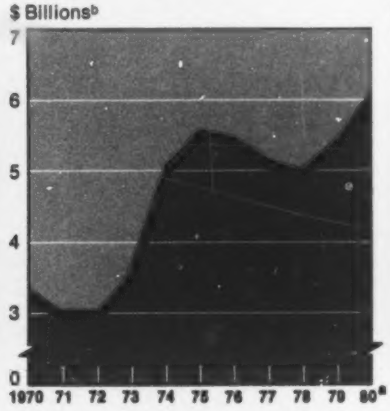
As a result, the ratio of constant-dollar spending to appropriations in the chemical industry has been sinking over the past year. After a near balance from 1975 through 1978, this ratio fell to 0.86 in 1979 and slipped further to 0.79 in first-quarter 1980.

The overhang of unspent funds eventually could become a windfall of new contracts for engineering companies, but there are no signs of anything like this now.

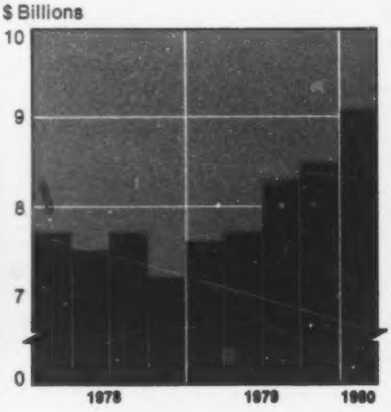
Chemical capital spending has been rising lately...



...but only modestly with inflation taken out...



...and backlogs of unspent appropriations are swelling



a Annualized rate in first quarter. b 1972 dollars. Source: Conference Board

business fixed investment in the U.S. will be down 2.5% in 1980 and down another 4.5% in 1981. Backlogs at the engineering companies are up only slightly if at all from last year. In constant-dollar terms, they are off considerably. (Backlogs represent future business for the engineering companies and are somewhat like inventoried demand.)

However, engineering companies say that although things don't look good right now, their profit picture could turn around quickly. In fact, one engineering company spokesman went so far as to say that he believes the recession for engineering-construction firms has bottomed out.

Although new orders are not flooding in at engineering companies, they all say that there is "increased activity." That means more inquiries, which company sources believe will turn into new orders.

All engineering firms agree that currently there is generally a high level of hiring of engineers as companies gear up for future business. However, since the level of actual engineering activity is rather low right now, there is some hiring of engineers who will not be kept very busy until the new business materializes.

Foreign business is picking up, according to the companies. It was slack for a while, but now there is heightened interest, especially in the Middle East, where oil producers want to put chemical plants close to their refineries so that they can get added value for their crude oil. U.S. firms, however, will not get all of this business. They are facing stiff competition from Japanese and West German engineering companies.

However, the synfuels program is the gleam in the eye of the engineering-construction firms. Many of the inquiries that they are receiving currently are about synfuels projects. And they blame the potential of the synfuels program for the present tightness in the engineering employment situation.

Just as the federally mandated environmental programs of the early 1970's used vast numbers of engineers, so the federally backed synfuels program is expected to soak up much of the available talent and still need more. Estimates are that it will take anywhere from 15,000 to 18,000 chemical engineers for the synfuels program alone once it gets started. So in many ways, in spite of complaints about the government, Washington is just about the best friend that the engineering companies have.

Even so, for the balance of 1980 and at least part of 1981, engineering-construction firms are looking for more difficult times. Farther off, the consensus in the industry is bright hopes. Middle East countries will want to get increased value for their oil, and the U.S. will wish to counter the high price of foreign oil with its own synthetic fuels program. □

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Engineering
NEWS

September [illegible], 1980

New productivity measures
for the chemical industry
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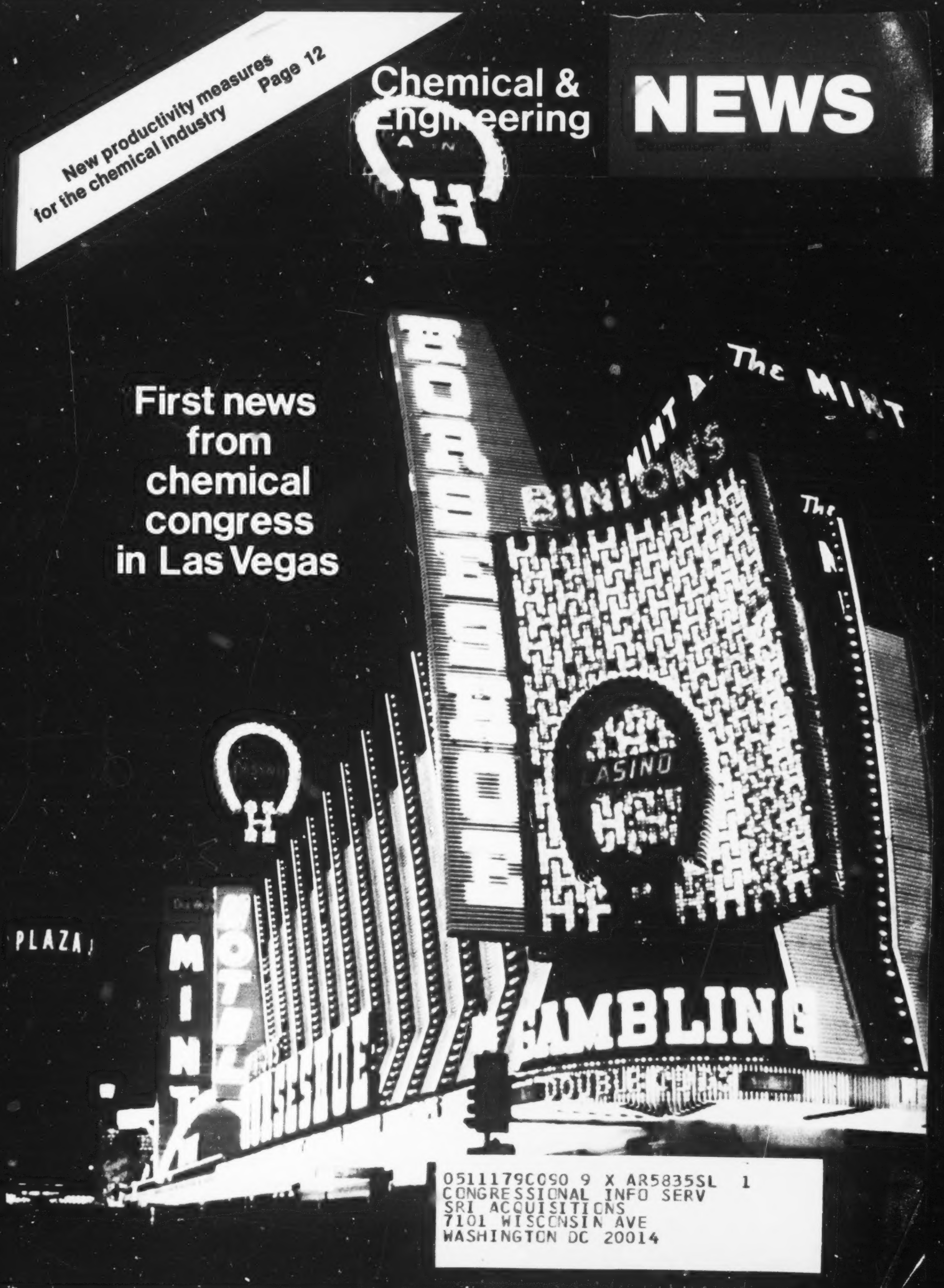
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First news from chemical congress in Las Vegas

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- ***People and places*** *filmed at the Las Vegas chemical congress include the city's mayor, keynote speaker Brown.* ***Page 6***
- ***Elimination of reproductive hazards*** *in the workplace was the subject of a Washington, D.C., conference of workers, union leaders, and social activists.* ***Page 8***
- ***Fragments of the human X chromosome*** *have been cloned for the first time by Johns Hopkins researchers who grew DNA from human cells in bacteria.* ***Page 8***
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- ***Process to remove residual polychlorinated biphenyls*** *from specialty industrial oils, developed by Goodyear, will go into the public domain.* ***Page 9***
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- ***Aerosol process*** *gives control over direct fluorination reaction, researchers tell Las Vegas congress.* ***Page 28***
- ***EPA's water quality criteria*** *cited for improper data collecting and manipulation by biologists at chemical congress.* ***Page 29***
- ***Yuriy Yarim-Agaev,*** *dissident Soviet polymer scientist permitted to leave the U.S.S.R., visits society headquarters.* ***Page 30***

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Letters

ACM and human rights

SIR: My attention has been called to the letter in C&EN, May 19, from Peter Lykos concerning the actions of the Association for Computing Machinery (ACM) in the human rights arena.

There was, indeed, as Lykos states, a ballot of the ACM membership in 1969. The question put was: "Shall the Constitution of the ACM be revised to permit Association comment or action in deeply political and social questions?" Answer, No, by four to one.

As always on such matters, controversy focuses on the interpretation of the action. I have consistently believed and so, too, have a majority of the ACM officers and Council, that the membership was telling us not to be involved in political and social questions with *no computing component* but that, when activities in support of our normal educational and scientific function also had political and social overtones, we were not barred from such actions. All of ACM's human rights activities and, I believe, those of other American scientific and engineering societies, have adhered to this principle.

The C&EN News Forum, April 21, page 37, on scientists and international politics was a careful look at both sides of this issue. I remain convinced that scientific societies are as effective a vehicle as exists for pursuing the human rights of persecuted colleagues, wherever they may be. And I have yet to see an iota of evidence that such activity weakens a society internally or reduces its influence externally. On the contrary, a perception by the world at large that scientists are also aware and caring human beings can only help us in influencing decisions on science that increasingly often have, like it or not, political and social components.

Anthony Ralston

Chairman, ACM, Committee on Scientific Freedom & Human Rights; (Past President of ACM, 1972–74), New York City

More on the pictograph

SIR: I would like to clarify some confusions that might have been caused by Kwang-Ting Liu's letter (C&EN, July 7, page 40). He emphasized the pictograph now used by the Chinese to denote steroid (R. J. Seltzer, C&EN, Dec. 17, 1979, page 25) was invented in the Han Dynasty and the Chinese chemists "borrowed" it and not "invented" it.

Let me point out that this pictograph (more correctly this Chinese word) was *invented* by the Chinese in the Han Dynasty carrying a different meaning and is now *used* by the Chinese to denote steroid. In the translation of nouns we are looking in one language for a word or a group of words that have the same meaning as a word in another language. This equivalence in meaning can be existing or assigned. The Chinese have taken a word in their vocabulary and assigned the meaning "steroid" to it. In other words they invented a new meaning for the already existing word. It is unequivocal that the Chinese invented the word and the Chinese use it.

Cheuk-Chung Yau

Kingsport, Tenn.

Feasibility of gasohol

SIR: In his letter about saving energy in gasohol production (C&EN, July 21, page 4) S. Arora raises the question of the feasibility of using gasoline to extract alcohol from an aqueous solution thereof and thereby saving the energy and capital associated with making anhydrous alcohol. Arora concludes, "Only an experiment will tell."

Well, the experiment's been done, quite some time ago, as a matter of fact. It worked fine within the limits of an unhappy phase diagram, and patent activity was initiated. However, there just didn't seem to be many locations where it would be logistically attractive to run 9 gal of gasoline into and out of the alcohol distillery for every gallon of alcohol made there. We therefore turned our attention to alternatives with some success.

At this point, because we're talking with candidate licensees, we can say only that we're very excited about our latest modification.

A. P. Gelbein

Director of R&D, ChemSystems Inc., Fairfield, N.J.

Nuclear safety—a rebuttal

SIR: Denis Burman has taken issue in C&EN June 23, page 4, with my letter in C&EN, March 31, page 3, in which I stated that "there is no

Correction

- Aug. 11, page 13: Stock market data are scrambled for final three companies in the earnings table for diversified chemical producers. Correct data are:

	Stock price			Price-earnings ratio	Annual indicated dividend	Dividend yield, % of price
		Recent 12 months				
	July 31	High	Low	July 31		
General Tire	$17	$\$23\frac{7}{8}$	$\$12\frac{1}{4}$	13	$1.50	8.8%
National Distillers	$28\frac{3}{4}$	$32\frac{1}{2}$	22	7	2.00	7.0
NL Industries	$49\frac{3}{4}$	$51\frac{7}{8}$	$23\frac{7}{8}$	12	1.20	2.4

New measures bear out productivity drop

Total-factor productivity indexes underscore gravity of U.S. productivity mass, show clearly that it touches the chemical industry

Bruce F. Greek
C&EN, Houston

The old saying, you can't define something you can't measure, applies with a vengeance to U.S. industry's productivity problem. Although everyone agrees that something is radically wrong and getting worse, it has been hard to say exactly how bad it is, how it got that way, and what to do about it.

Theories abound, from poor labor efficiency to deteriorating management to slowed capital formation to sluggish support of research and development. But the truth is, productivity is still somewhat of a mystery, even though its growth is a simple concept: Output grows faster than labor, capital, and other inputs.

A large part of the mystery is that productivity measures haven't been very good. The partial industry measures to date from the government have concerned only labor productivity, which for an industry like chemicals is a small part of total productivity.

A bold stroke on the statistics front now comes from the American Productivity Center in Houston. APC is offering a new data service providing indexes on "total-factor" productivity for all major sectors of the U.S. private business economy, including the chemical industry.

Although not as yet a true "total" productivity series, the new indexes represent a significant step in the right direction, according to C. Jackson Grayson Jr., chairman of APC. Containing a new factor for real-dollar capital inputs, these indexes are superior to productivity measures based entirely on labor input, especially for industries like chemicals that are capital intensive. In addition, the new indexes cover whole industries in line with standard measures such as production and employment.

A complete total-factor productivity measure also would include factors for energy and raw materials inputs. APC is working on this grand design and intends eventually to offer it as a companion service.

Total-factor productivity indexes now offered cover the years 1948 through 1978 for specific industries

Productivity growth is way down although capital inputs have risen faster than labor

Index, 1967 = 100	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1968
Total-factor productivity											
Chemical industry	134.0	133.3	130.3	123.2	122.5	135.1	128.3	118.5	112.7	112.4	110.1
All manufacturing	120.1	118.7	114.8	109.4	107.2	114.4	110.9	105.3	101.2	103.3	102.9
Output per unit labor											
Chemical industry	150.8	147.7	142.8	134.8	129.6	141.2	134.9	121.4	115.4	112.9	110.0
All manufacturing	129.1	127.8	123.9	119.2	113.1	118.9	115.9	110.9	105.2	104.9	103.9
Output per unit capital											
Chemical industry	113.7	115.2	114.1	108.0	112.4	126.2	118.6	110.2	108.2	111.3	109.7
All manufacturing	101.3	99.8	95.8	89.5	94.4	104.8	100.0	93.2	92.8	100.8	101.8
Real output											
Chemical industry	164.7	158.0	148.4	134.3	136.7	146.8	136.2	125.2	120.9	120.0	113.8
All manufacturing	134.5	128.2	119.5	109.1	114.9	123.2	113.7	104.0	102.6	108.7	105.6
Labor input											
Chemical industry	109.2	107.0	103.9	99.6	105.5	104.0	100.9	100.9	104.7	106.3	103.5
All manufacturing	104.1	100.4	96.5	91.5	101.6	103.6	98.1	93.8	97.5	103.6	101.7
Capital input											
Chemical industry	144.9	137.1	130.1	124.3	121.6	116.4	114.3	113.6	111.7	107.8	103.7
All manufacturing	132.7	128.5	124.7	121.9	121.7	117.6	113.7	111.6	110.5	107.9	103.8
Capital-labor ratio											
Chemical industry	132.7	128.2	125.2	124.8	115.3	111.9	113.7	112.7	106.6	101.4	100.2
All manufacturing	127.4	128.1	129.3	133.2	119.8	113.4	116.0	118.9	113.3	104.1	102.1
Total-factor input											
Chemical industry	122.9	118.5	113.9	109.0	111.6	108.7	106.2	105.7	107.3	106.7	103.4
All manufacturing	111.9	108.0	104.1	99.7	107.2	107.7	102.5	98.8	101.3	105.2	102.7

Source: American Productivity Center and through 1979 for industry as a whole. Overall data for private U.S. business show compound annual growth in output of 3.6% over three decades. At the same time, labor and capital inputs rose a combined 1.3%, leaving total-factor productivity rising at 2.3%.

For the chemical industry, the 30-year annual compound output growth was a bit under 5.8%. Inputs rose 2.8% per year, and total-factor productivity 2.9%. For all manufacturing, output grew 3.5% per year, inputs 1.4%, and productivity 2.0% (the numbers don't add up exactly because of rounding).

So far, chemicals look pretty good. But closer examination reveals disturbing trends, which add up to a slowing in productivity growth, more so in recent years for chemicals than for manufacturing as a whole.

Chemicals continued to outgrow manufacturing in relative productivity from 1965 to 1973 with annual growth of 3.6% compared to manufacturing's slowed 1.8%. However, after that the real trouble started in an environment of overinvestment, severe recession, and reduced product growth. From 1973 through 1978, APC data show the chemical productivity rate falling all the way to an average 0.2% yearly decline. Manufacturing productivity growth eased to 1.0% per year.

The ratio of capital to labor in business inputs grew even faster in the most recent 10 years for both chemicals and all manufacturing. As C&EN and other surveys show, both groups' role in job formation has slowed drastically in recent years. However, even a relatively greater role for investment capital in chemical industry growth couldn't stop a decline in productivity growth.

The decline in total-factor productivity growth for all manufacturing and many of its segments, in-

Total-factor productivity considers variety of inputs

Although more complicated than older measures, total-factor productivity provides a much more comprehensive way to treat the major influences on production efficiency. In equation form, it looks like this:

Total-factor productivity =
Output/Capital + Energy +
Labor + Materials (inputs)

That is, productivity is physical output per unit of capital, unit of energy, unit of labor, and unit of raw material.

By contrast, the older concept of productivity as only output per unit of labor leads to distortions. In particular, it doesn't take into account substitution of capital for labor and thus overstates gains in labor efficiency. Total-factor indexes run lower than conventional productivity measures.

Put another way, the new indexes show an apparent dampening effect on productivity gains from relatively greater capital use. Some of this is logical. For example, capital represented by environmental equipment has no effect on output and thus lowers productivity gains. But much of the problem is still a mystery even to the experts.

Total-factor productivity measures also help avoid confusion between production and productivity. Production gains tell nothing about productivity without examination of the relative levels of the four major inputs.

Finally, the new indexes are a step toward linking profitability and productivity. Profitability is productivity times "price recovery." Price recovery is the change in the price of a unit output compared to the change in cost of the various units of input. It's what company people mean by "cost passthroughs" and similar terms.

										Average annual change, %	
1967	1966	1965	1964	1963	1962	1961	1960	1959	1958	1968-78	1958-68
100.0	102.5	101.5	96.8	91.1	83.1	79.1	77.1	78.9	70.9	2.0%	4.5%
100.0	100.8	99.3	96.0	91.4	85.7	81.9	81.1	80.4	76.4	1.6	3.0
100.0	101.9	100.7	95.7	89.6	81.7	78.2	75.6	76.9	69.1	3.2	4.8
100.0	99.3	97.9	95.1	90.3	84.4	81.1	79.5	78.4	75.5	2.2	3.2
100.0	103.2	102.4	98.2	93.0	84.8	80.3	79.1	81.6	73.2	0.4	4.1
100.0	105.2	103.5	98.6	94.5	89.3	84.1	85.7	86.5	79.1	−0.1	2.6
100.0	98.8	92.4	84.4	78.0	69.9	65.0	62.7	62.5	54.2	3.8	7.7
100.0	100.0	92.6	84.9	79.1	73.3	67.4	67.7	67.2	60.3	2.5	5.8
100.0	96.9	91.8	88.2	87.0	85.6	83.2	83.0	81.3	78.4	0.5	2.8
100.0	100.7	94.5	89.3	87.6	86.8	83.1	85.2	85.7	79.9	0.2	2.4
100.0	95.7	90.2	86.0	83.8	82.5	81.0	79.2	76.6	74.1	3.4	3.4
100.0	95.0	89.5	86.1	83.8	82.1	80.2	78.9	77.7	76.3	2.5	3.1
100.0	98.8	98.3	97.4	96.4	96.4	97.4	95.5	94.3	94.5	2.9	0.6
100.0	94.3	94.6	96.4	95.6	94.5	96.5	92.7	90.7	95.5	2.2	0.7
100.0	96.4	91.1	87.2	85.6	84.2	82.2	81.3	79.2	76.5	1.7	3.1
100.0	99.2	93.2	88.4	86.6	85.6	82.3	83.5	83.6	79.0	0.9	2.7

Celanese Chemical uses three-pronged approach to improve productivity

"Recommitment to productivity improvement" is how Huey P. Prater, productivity manager of Celanese Chemical, terms his company's program for tackling a job facing most of U.S. industry. After three years, Prater claims Celanese Chemical has tangible results from its efforts. For example, at one major complex in Bishop, Tex., a three-year program shows a 15% improvement in productivity.

Other Celanese Chemical units have similar programs in what is called "productivity management." The basic objective of these programs is to integrate productivity improvement into the mainstream of management, Prater says, as part of the long-range development of the corporation.

This longer-term outlook differs radically from most day-to-day industry planning. At Celanese Chemical, longer term means productivity planning over a two- to three-year period.

The Celanese Chemical program falls into three major segments—productivity awareness, productivity monitoring (a form of scorekeeping), and employee awareness.

Productivity awareness is largely up to Prater. In effect, he becomes a member of a plant manager's staff for a short period. During this time, he conducts informal interviews of a cross section of plant personnel to discover their opinions on major productivity problems at the plant and ways to correct them.

At the same time, Prater analyzes plant statistics of many kinds—production efficiency, backlogs, overtime, and others. Engineering projects are studied for timeliness and the like. Outside influences such as vendor delays are not taken into consideration.

The monitoring or scorekeeping segment involves accounting department services. Computer programs are used to develop indexes similar to the new total-factor productivity indexes developed by the American Productivity Center. Prater spent a year at APC learning about productivity improvement.

Wherever possible, these new productivity measures use physical quantities such as pounds of production. Dollar figures are deflated to constant dollars. Indexes are used only when it isn't practical to obtain physical quantities.

Of the three segments in Celanese Chemical's productivity program, employee awareness falls shortest of the optimum, in Prater's opinion. The major reason is a lack of good means of communication. Celanese Chemical is slowly developing materials such as audiovisual aids, written material, and oral programs for this purpose and has used materials developed by APC and others.

Even so, it is the employee awareness segment that has produced the biggest surprise for Prater. Once the need is made clear, employees show a great willingness to participate in various programs, large and small, aimed at improving productivity.

When the productivity improvement program was begun in 1977, the Bishop complex was selected as a test case. The plant manager there, Paul E. Hime, was very interested in productivity improvement, and a large site with a diverse product slate was needed to ensure that results were generally valid.

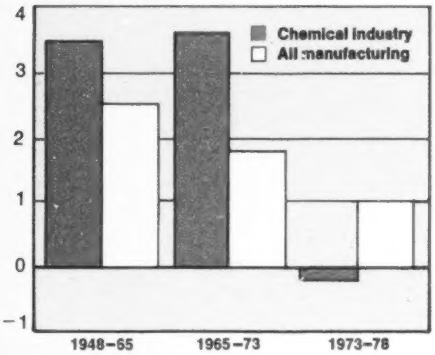
Prater says that valuable results have come from the three-year program at Bishop. For example, this plant leads all Celanese Chemical plants in energy conservation.

Efficiency in raw materials use also has improved at Bishop, helping productivity. Frequently this is achieved by using new technology such as switching from a high-pressure to a low-pressure process for making methanol.

The three-year program at Bishop with its 15% productivity improvement typifies what productivity improvement is all about, Prater says. There is no magic solution; improvement requires dogged effort, time, patience, and real cooperation. However, Prater fully expects that total-factor productivity indexes will in time become a meaningful management tool.

cluding chemicals, has become widely recognized as the "stagflation" of the mid- and late 1970's. The total-factor productivity measurements help identify the core problems causing declines in productivity, says Carl G. Thor, vice president, measurement, of APC. Examples of these problems, he says, are the relatively low rate of capital formation in the U.S. because of high taxes and lack of business incentives common in other countries, a holdup in private R&D expenditures except for defensive work, and mandated heavy investment in environmental control equipment.

Total-factor productivity in chemical industry has fallen



Source: American Productivity Center

But Thor believes that identifying these problems, in part through better measurement, goes a long way toward their solution. The solution will involve a lot of management planning following comparison of productivity measures with other company analysis systems, goals, and management styles.

Even with such management backing, productivity campaigns have another serious hurdle—personnel cooperation. Productivity doesn't have a good general image, Thor admits. Many employees and managers believe that productivity efforts bring job risks or at least a call to work harder.

However, Thor says that new ways have been found to involve workers and managers in productivity improvement without losing the essential morale. Some U.S. industries such as aircraft and chemicals are adopting the Japanese "quality circle" technique of voluntary participation of a work group in suggesting improvements after discussing their work environments. Celanese Chemical, for instance, has used this and other techniques in a broad program to boost productivity.

APC's statistics development traces to an approach pioneered by John W. Kendrick, former chief economist of the Department of Commerce, former vice president of the Conference Board in New York City, and now a member of the APC board of directors. Data compilation is the work of Elliott S. Grossman, a former coworker of Kendrick's at the Conference Board and now professor at Pace University in New York City.

Although the APC indexes help clear up the nature of the U.S. productivity problem, for the moment many subscribers will wish they didn't know so much. For the chemical industry itself, the total-factor productivity index must be a jolt and could direct more management attention toward reversing the index's recent direction. ☐

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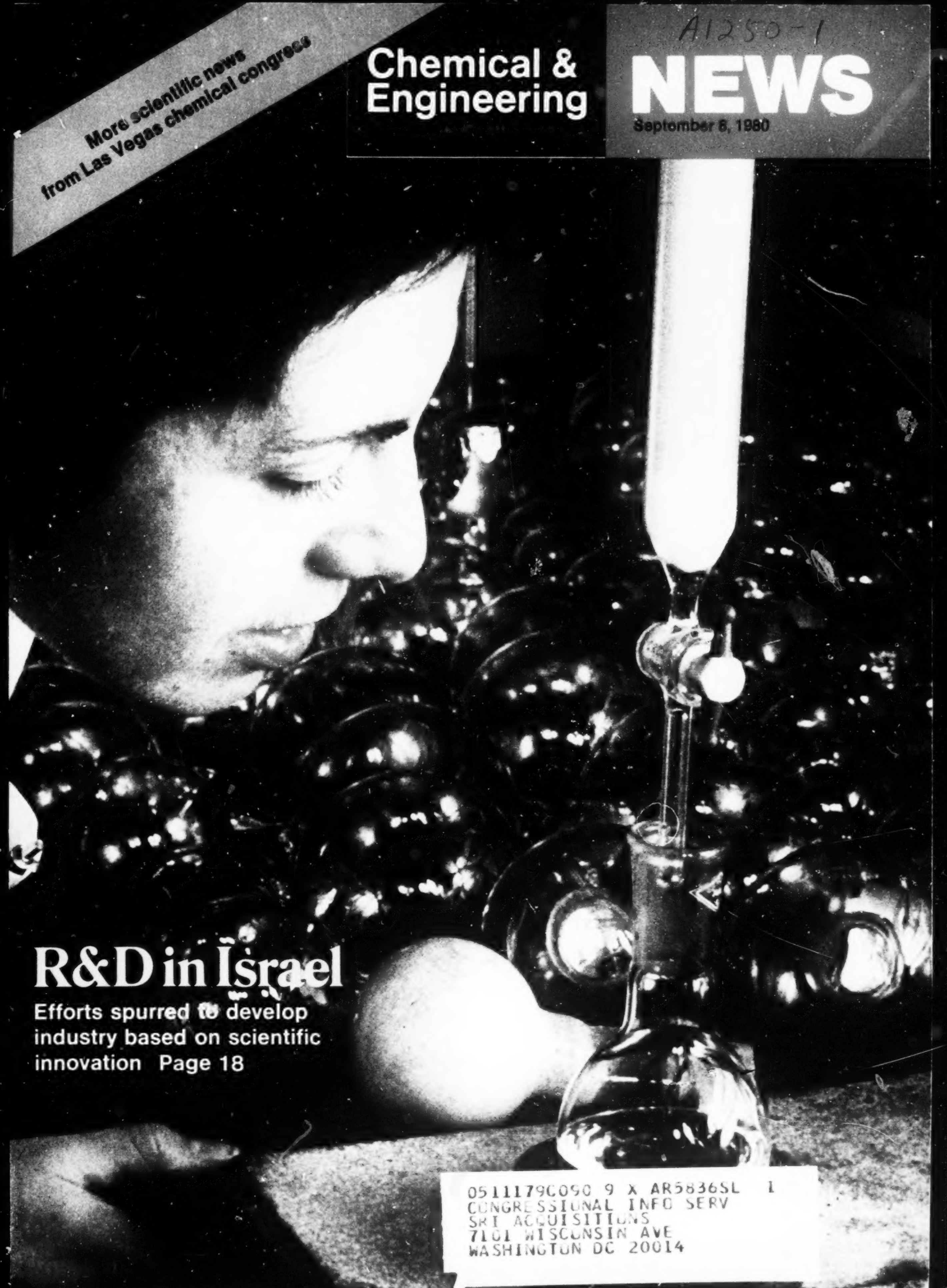
Chemical & Engineering NEWS

September 8, 1980

More scientific news from Las Vegas chemical congress



R&D in Israel

Efforts spurred to develop industry based on scientific innovation Page 18

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Cover: Scientist carries out chromatographic separation at Weizmann Institute of Science, Rehovot, Israel. (Weizmann Institute photo, supplied by courtesy of Embassy of Israel, Washington, D.C.)

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- ***Thermodynamic data bank*** *on pure compounds contains critical properties, equation of state data, other information.* ***Page 6***
- ***Department of Energy offers $5 billion*** *in loan and price guarantees, purchase commitments for synfuels plants.* ***Page 7***
- ***EEC imposes provisional antidumping duty*** *for four months on some polyester yarns imported from the U.S.* ***Page 7***
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- ***Israel's development of industrial R&D*** *based on scientific innovation; emphasizes moving away from basic research toward applied and industrial research.* ***Page 18***

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U.S. CHEMICAL INVESTMENT ABROAD RISING

Last year U.S. chemical companies increased their investments outside the U.S. more than foreign companies raised their chemical investments in the U.S., according to surveys by the Department of Commerce.

Specifically, U.S. chemical companies hiked investments to $19 billion overseas in 1979, an 18.5% increase over 1978. At the same time, foreign companies increased their chemical investments in the U.S. 16.2% to $7.1 billion.

By the end of 1979, U.S. chemical companies' investments abroad made up 9.9% of all U.S. overseas investments. Foreign investments in U.S. chemicals accounted for 13.5% of all foreign investments in the U.S.

Growth of U.S. chemical investment abroad outpaced that of total U.S. investment overseas, which rose 14.8% to $193 billion in 1979.

Both U.S. investment in chemicals and total investment abroad were highest in Western Europe, according to the Commerce Department. U.S. chemical investment in Europe rose 24.1% last year to $9.8 billion, total U.S. investment there rose 17.1% to $81.5 billion.

Even though increases in U.S. chemical investment abroad were large, U.S. oil company investments overseas were larger still. U.S. petroleum firms increased their total overseas investments to $41.6 billion by the end of 1979, a 23% rise from 1978. These firms' investments in Europe also increased nearly 23% to $18.6 billion.

U.S. chemical companies' money outflows in equity and intercompany accounts for foreign operations decreased 37.2% in 1979 to $715 million. Most of this—$473 million—was from Europe. Outflows in equity and intercompany accounts for all U.S. firms' foreign operations increased 21.1% in 1979 to $5.9 billion.

Reinvested earnings at U.S. chemical firms' foreign operations rose about 68% to $2.2 billion in 1979. The biggest such increase was in Canada, where reinvested earnings rose 254% from 1978 to $350 million. Reinvested earnings for all U.S. companies' foreign operations increased nearly 61% to $18.4 billion.

Income derived from U.S. chemical companies' foreign operations also showed a healthy increase in 1979. It rose 57.6% from the year before to $3.2 billion. Again, the bulk of this came from Europe—$2.0 billion, a 76.2% increase over 1978. However, the largest percentage occurred in Canada, where U.S. chemical income jumped 116% to $516 million.

On the other hand, foreign companies' income from U.S. chemical operations increased 13.2% in 1979 to $430 million. This is considerably lower than the 43% increase in income from total U.S. investment of foreign companies.

Money outflow in equity and cash accounts for the U.S. chemical investments of foreign companies decreased 6.4% in 1979 to $743 million. And reinvested earnings increased 27% to $234 million. □

Chemical investment overseas rose 18% in 1979, while foreign investment in U.S. chemicals increased 16%

$ Millions	Cumulative investment at year's end 1979	1978	Outflow[a] 1979	1978	Reinvested earnings[b] 1979	1978
U.S. DIRECT INVESTMENT ABROAD						
All areas	**$192,648**	**$167,804**	**$5904**	**$4877**	**$18,414**	**$11,469**
Petroleum	41,553	33,790	2730	412	4,979	1,355
Chemicals	18,990	16,026	715	1139	2,224	1,321
Europe	**81,463**	**69,553**	**1246**	**2447**	**10,522**	**5,666**
Petroleum	18,555	15,122	439	728	2,947	213
Chemicals	9,776	7,876	473	355	1,411	785
Canada	**41,033**	**37,071**	**915**	**−600**	**2,884**	**1,724**
Petroleum	9,168	8,246	5	−437	828	564
Chemicals	3,246	2,875	24	394	350	99
Latin America	**36,834**	**32,662**	**1454**	**2204**	**2,589**	**2,096**
Petroleum	4,568	3,892	38	218	623	187
Chemicals	3,632	3,250	96	277	284	300
FOREIGN INVESTMENT IN U.S.						
Total	**$52,260**	**$42,471**	**$5984**	**$5313**	**$3,729**	**$2,583**
Petroleum	9,903	7,762	526	303	1,615	940
Chemicals	7,081	6,094	743	794	234	184

a Equity and intercompany accounts. b For incorporated affiliates. Note: Negative number means net inflows to U.S.
Source: Department of Commerce

Thermodynamic data bank now available

In a move to help quench industry's thirst for reliable and badly needed standard reference data, the Thermodynamics Research Laboratory (TRL) at Washington University, St. Louis, has just released an extensive data bank containing thermodynamic data on pure compounds. In preparation for the past decade, the data bank is part of the laboratory's correlation package, a thermodynamic data system that also will include data on mixtures.

TRL director Buford D. Smith says that the data banks are the result of combing through 25,000 literature documents, collecting, processing, and critically evaluating the data, and organizing them on computer tape.

The data system is an ongoing project that is far from complete, however. The released data bank covers only 383 hydrocarbons in the C_3 to C_9 range. Entries for these include pure compound constants, such as melting and boiling points and critical properties; vapor pressure, liquid density, and second virial coefficients as a function of temperature; and equation of state data. The pure compound data bank will be updated every six months as new compound classes are added. Alcohols and ketones, for instance, are slated for inclusion in the data bank soon. Other types of data, such as heat capacities and heats of formation, will be added shortly; data on transport

Chemical stocks are still a bargain

For many chemical firms, however, stock prices are beginning to overtake book values; result may be a slowing in merger activity

It is little wonder that chemical companies are attractive takeover targets. Profitability generally outpaces the average for all manufacturing. Labor costs are relatively low in terms of other industries. There is enough of a countercyclical nature to the product mix that there are not the wild swings in earnings performance that occur in autos or construction. And chemical companies are very cheap.

For some time now, the price of the stock of many chemical companies has not kept pace with the book value of these companies. Book value is the assets of the company minus the liabilities; it is, in effect, the theoretical liquidation value of the company. Thus, if a company that has a stock price lower than its book value per share were to be liquidated, stockholders would make more money than they would have had they sold their stock. When an acquiring company buys a firm with a stock price lower than book value, it is buying assets at a greatly reduced price.

For instance, Union Carbide's stock on Aug. 27 closed at $46.75 per share. This is $21.66 below its book value per share of $68.41 at the end of the company's second quarter. Put another way, its stock price to book value ratio on Aug. 27 was 0.68 or 68%.

During the past year chemical companies' rating on Wall Street has improved. The stock price/book value ratio has climbed for a group of 20 companies surveyed by C&EN. On July 31, 1979, the median stock price/book value ratio for these 20 companies was 0.95. By the same date in 1980, the median ratio had climbed to 0.97. And by Aug. 27, the median actually hit 1.00. In other words, on that date the shares were selling at their liquidation values.

The average stock price/book value ratio looks better than the median for the 20 companies. On July 31 last year, the average ratio was 1.18. A year later it had risen to 1.35. And on Aug. 27, it was 1.44. This average was in part raised by increasing stock prices, but it was paced by some smaller chemical companies on the list such as Petrolite and First Mississippi.

Petrolite had a stock price/book value ratio on Aug. 27 of 4.59; First Mississippi a ratio of 3.61. Others with stock prices exceeding book value include Nalco Chemical with a ratio of 2.95; Air Products, 2.05; Mallinckrodt, 1.57; Diamond Shamrock, 1.42; Dow Chemical, 1.38; W. R. Grace, 1.25; Du Pont, 1.16; and Rohm & Haas, 1.02.

In all cases, in the past year book value for the companies surveyed has risen. But the stock price in general has risen much faster. The runup in chemical stocks in the past few months (C&EN, Aug. 18, page 6) means that the ratio has risen. However, there still are many companies that are greatly undervalued and show a lot of potential for improvement. In fact, since the median on Aug. 27 was 1.00, exactly half of the 20 companies surveyed have a stock price/book value ratio of less than 1.00.

The company with the lowest ratio is Hercules at 0.47 followed by Olin at 0.64, Carbide at 0.68, Monsanto at 0.69, Celanese at 0.72, and Pennwalt at 0.80. The rest of the companies below 1.00 fall in the 0.90 to 1.00 range.

The outlook for the companies' valuations is good, barring some untoward event such as double dip recession. With the stock market in general moving up and with chemical stocks outperforming the total market growth, the stock price/book value ratio for chemical companies probably will continue to increase.

Thus, chemical companies will become less attractive as takeover targets on a strictly price basis and, when takeovers do occur, it will not be because a company can acquire greatly undervalued assets.

William Storck, New York

Stock price had risen to firms' liquidation value near end of August

	Book value per share[a]		Stock price			Stock price/book ratio		
	Second quarter 1980	1979	Aug. 27, 1980	July 31, 1980	July 31, 1979	Aug. 27, 1980	July 31, 1980	July 31, 1979
Air Products	$22.72	$19.36	$46½	$45	$34⅞	2.05	1.98	1.80
Allied Chemical	57.05	46.06	53¼	51¼	35⅝	0.93	0.90	0.77
American Cyanamid	28.91	27.20	27½	28	25	0.95	0.97	0.92
Celanese	74.54	69.33	53⅝	53	45¼	0.72	0.71	0.65
Diamond Shamrock	21.78	18.13	31	31⅝	24⅞	1.42	1.45	1.37
Dow Chemical	25.44	20.20	35⅛	36½	28	1.38	1.43	1.39
Du Pont	38.69	35.36	45	43	40⅞	1.16	1.11	1.16
Ethyl Corp.	32.23	28.98	30½	31⅜	28⅜	0.94	0.97	0.98
First Mississippi	13.14	8.39	47⅜	40¾	15⅛	3.61	3.10	1.80
W. R. Grace	35.29	32.74	44⅛	43¾	30	1.25	1.24	0.92
Hercules	44.61	40.46	21	19¼	20	0.47	0.43	0.49
Mallinckrodt	24.67	23.16	40¼	36½	28½	1.57	1.42	1.23
Monsanto	80.63	75.76	55¾	55⅜	52¼	0.69	0.69	0.69
Nalco Chemical	14.05	12.20	41½	40½	32⅜	2.95	2.88	2.65
Olin	32.40	30.31	20⅝	20⅛	22⅞	0.64	0.62	0.75
Pennwalt	37.26	35.24	29¾	29¾	32	0.80	0.80	0.90
Petrolite	17.23	15.11	79	65	47	4.59	3.77	3.11
Rohm & Haas	52.82	46.77	53⅝	47⅜	43	1.02	0.90	0.92
Stauffer Chemical	20.86	18.84	20¼	19⅞	23¼	0.97	0.95	1.23
Union Carbide	68.41	58.67	46¾	43¾	40⅝	0.68	0.64	0.69
MEDIAN						1.00	0.97	0.95

a Stockholders' equity divided by number of shares of common stock outstanding.

Israel spurs development of industrial R&D

Efforts mount to promote industry based on scientific innovation; balance shifts from basic toward applied research

Richard J. Seltzer
C&EN, Washington

"There will come an age of small and independent nations whose front line of defense will be knowledge." (Charles P. Steinmetz, 1865–1923)

"Moses made a wrong turn while he was leading the Children of Israel through the wilderness toward the Promised Land. If only he had turned right, toward the Persian Gulf—instead of left, toward the Mediterranean! We could now be floating in oil!" (current Israeli joke)

Nothing could be more relevant to the situation of the state of Israel since its founding in 1948 than these words from electrical pioneer Steinmetz or this popular Israeli joke.

Sited at the heart of the critical and explosive Middle East, Israel is beleaguered by heavy economic, social, political, and military pressures. In confrontation with its neighbors except for a fragile new peace treaty with Egypt, strained by an economy with an inflation rate of 111% last year and a government budget devoting about a third to defense and almost another third to debt service, beset by the problems of integrating previous immigrants from African and Asian lands with low educational levels and of absorbing new immigrants from the U.S.S.R. and other developed lands with high educational levels, Israel is par excellence a small nation whose front line of defense and future growth and welfare depend critically upon knowledge—particularly scientific and technological knowledge.

Moreover, there is an important point to the joke about Moses' "wrong turn," wryly related in different versions to a recent visitor to Israel by several leading Israeli scientists and science administrators. The point is that Israel imports most of its fuel supplies—putting a soaring burden on its balance of payments—and has few other natural resources. (Fuel imports are expected to cost about \$2.4 billion this year.) Its only sizable resources are salts from the Dead Sea, phosphates, and the sun.

"The main natural resource that we have is brain power," they stress, "so we have to rely on this to make our way in the world."

In fact, perhaps no relatively new and developing country has made science and technology so central an element in its development strategy—and indeed its survival. In particular, the two outstanding successes have been development of efficient, science-based agriculture and creation of a highly sophisticated, R&D-based defense establishment.

Now science is being called on to do the same for industry. Israel gives top priority to expanding industry in its current efforts to reduce its huge foreign trade imbalance (about \$3.8 billion in 1979) and to lessen its economic dependence on foreign loans and grants. And the type of industry that Israel must nurture, officials stress—with high export potential, high added value, a minimum of raw materials, and maximum exploitation of the country's highly skilled but relatively low-cost manpower—is industry based on science and high technology in chemical and other areas.

"All of us realize that the future of our industry is in technological innovation," emphasizes Arieh Lavie, chief scientist at the Ministry of Industry, Trade & Tourism. "This is the main advantage that we have in this country for our industry. We don't actually have any other advantage."

This has led to several results:

- An intensifying government effort to promote R&D with industrial potential at Israel's research labs, both in industry and in academia.
- Successful development of science-based industry in electronics, certain chemical-related areas, and other fields.
- A start at shifting the center of gravity of Israel's scientific community from basic research to applied and industrial research, propelled by government funding policies.
- Development at Israeli labs of a number of new ideas with commercial potential, some already drawing interest and involvement by foreign firms.

At Desert Research Institute in Sdeh Boker, Aharon Abelovich checks algae-growing ponds

Israel has built up a world-class research establishment in its 32 years, with pioneering achievements in a number of fields. It currently spends about \$300 million (about 2% of its gross national product) on civilian and military R&D together, about 53% of this for civilian R&D. This is comparable to R&D spending by the U.S. (2.3% of GNP) and other developed countries.

Moreover, relative to its population of about 3.8 million, Israel has more scientists and engineers engaged in R&D than do the U.S., Japan, or West European countries. More Israeli scientists publish papers in international scientific journals, relative to their nation's population, than do scientists of other lands. And in 1975, the latest year for which figures are available, Israel awarded more master's and doctorate degrees in the

C&EN staff photo

natural sciences, relative to population, than any other country.

However, Israel's high rate of scientific publication reflects another characteristic besides research productivity—an "inverted pyramid" structure for Israeli science. Other countries generally have a broad foundation of scientists working at applied and industrial R&D, with a smaller basic research apex. Israel has had just the opposite, with most of its scientists working on basic research at academic institutions (and hence more prolific at publishing papers).

Thus, in 1972–73 Israeli industry carried out only 18% of all civilian R&D. Academic institutions did 61%, government research institutes did 19%, and hospitals 2%. Industry carried out even lower fractions of the R&D in previous years.

This inverted pyramid has existed since before Israel became independent in 1948. Israeli science started with establishment of universities and research institutes, in particular three major institutions: Technion-Israel Institute of Technology in Haifa and Hebrew University of Jerusalem in the 1920's, and Weizmann Institute of Science in Rehovot in the 1940's. (Weizmann Institute, formally established in 1949 as primarily a basic research institute, grew out of Daniel Sieff Institute, which was founded as a largely applied research institute in 1934 by Chaim Weizmann, a leader of the Zionist movement and a noted chemist, later first president of Israel.)

These three institutions have been joined since by four more universities—Tel Aviv University and Bar Ilan University in the 1950's, and Ben-Gurion University of the Negev and University of Haifa in the 1960's. A scientific elite grew up that did high-prestige basic research and that in many cases looked down with disrespect on applied research and industry. There was relatively little academic-industrial communication or collaboration.

The other side of the coin was a dismal scene for R&D and innovation in industry. With a few exceptions, industry was based on technology readily available or bought abroad—what one Israeli science administrator, Zvi Pelah, director of the R&D Authority at Ben-Gurion University, describes as "simply filling bottles." Industry was mostly too small and unsophisticated to carry out R&D, and industrial managers did not have the background or orientation to appreciate what R&D could do for them. (Among the exceptions was work on exploiting Dead Sea salts and on use of solar collectors for home water heating.)

For many years, Israelis have talked about the need to change this situation, and to focus their high-powered scientific establishment to a much greater degree on Israel's practical economic needs, particularly industrially oriented R&D. Now, by all indications, they finally have begun to do it.

The change during the past few years is dramatic, as shown in three sets of figures cited by Lavie. In 1973, only about 19% of Israel's civilian R&D spending was devoted to industrial R&D, compared to rates of 60% in the Netherlands, 70% in the U.S., and 80% in Switzerland. However, this year close to half of Israel's civilian R&D is in industrially related areas. And Israel aims to raise the balance to 60% industrial research, and 40% basic research.

Moreover, Lavie explains, industrial exports resulting from Israeli R&D have soared more than 30% a year in recent years—from $349 million in 1976 to $783 million in 1979.

Israel sets goals for rapid growth in industrial R&D

Israel has put R&D at the center of its ambitious plans for development of industry, including chemical industry, during the next decade. Top priority thus goes to beefing up industrial R&D, previously underdeveloped in Israel, including:

- **Increased spending on industrial R&D, going from about $6 million in 1970 to about $70 million in 1979 (exclusive of buildings and equipment).**
- **Shifting the balance between industrial and academic research, with industrial R&D rising from 19% of civilian R&D spending in 1973 to about 50% this year and a goal of 60% in the next few years.**
- **Rapid growth in industrial exports based on Israeli R&D, from about $20 million in 1972 to $783 million in 1979 and a projected $4 billion by 1990—going from 4% of all industrial exports in 1972 to 31% in 1979 and close to half by 1990.**
- **More than tripling the number of R&D scientists and engineers in industry, from 1438 in 1975 to 4670 by 1983, including an increase in chemists and chemical engineers from 341 to 1120.**

This includes both locally developed products and exports produced using locally developed processes, such as heavy chemicals. Last year, about one third of Israel's industrial exports of $2.5 billion (excluding processed diamonds) resulted from local R&D, compared to only 4% of industrial exports as recently as 1972. The goal is to increase exports based on local R&D to $4 billion by 1990 (about half of all industrial exports).

Manpower figures also demonstrate the trend, Lavie adds—and the major place given to chemical R&D. Israel has about 10,000 scientists and 20,000 engineers, he notes. Of these, 2580 worked on R&D in industry in 1979, including 410 chemists and 210 chemical engineers (plus about 400 additional scientists and engineers doing industrially oriented research at research institutes and universities). These figures represent an increase of about 80% in both cases from those doing R&D in industry in 1975 (1438 total scientists and engineers in 1975 and 341 chemists and chemical engineers). The aim is to increase R&D scientists and engineers about 16% a year to 4670 by 1983, including 750 chemists and 370 chemical engineers.

R&D supplies growing share of Israel's industrial exports . . .

$ Millions	Industrial exports based on local R&D[a]	All industrial exports[b]	% based on local R&D
1972	$ 20	$ 527	4%
1973	101	626	16
1974	233	928	25
1975	290	970	30
1976	349	1228	28
1977	433	1551	28
1978	513	1923	27
1979	785	2545	31
1980[c]	1000	3250	31
1990[c]	4000	na	na

a Includes both locally developed products and exports produced using locally developed processes, such as heavy chemicals. b Excluding processed diamonds. c Projected. na = not available. Sources: Israeli Ministry of Industry, Trade & Tourism, and Government of Israel Trade Center

. . . and chemical industry supplies almost one third

$ Millions	Chemical exports	% of all industrial exports[a]
1972	$134	25%
1973	161	26
1974	349	38
1975	321	33
1976	342	28
1977	442	28
1978	528	27
1979	726	29

a Excluding processed diamonds. Source: Israeli Ministry of Industry, Trade & Tourism.

Young scientists now are much more willing to work on applied and industrial research than 10 or 15 years ago, adds Ephraim Katchalski-Katzir, a noted chemist and former president of Israel. They are beginning to realize that applied research can be of great interest and can be done at a high scientific level, he explains. In addition, there are now only very limited positions open for doing basic research.

Israel is developing a variety of mechanisms to encourage industrial R&D and innovation, and some Israelis believe that their methods may be useful for other developing countries. A central role in funding and coordination is played by the Office of the Chief Scientist that Lavie heads at the Ministry of Industry, Trade & Tourism. The office has a research fund that will spend about $40 million this year to support some 600 R&D projects at about 300 Israeli firms, as well as about 200 long-range projects at research institutes and universities.

The fund has doubled in size during the past three years, and supplies about half the industrial R&D funding in Israel. (Industry supplies the other half.) One survey of its effectiveness showed an increase of about $9.00 in industrial exports during 1972–76 for each dollar in grants in 1970–74. Most of the industrial R&D is done in company labs, with some subcontracting to academic labs.

Grants are given by Lavie's office for 30 to 100% of the costs of R&D projects. The office gives 50% of costs when the product or process is intended primarily for export and the market has been clearly demonstrated. (Most approved projects fall into this category.)

It gives up to 80% for what are called "national projects" or "projects of national importance"—when the size, importance, potential return, and greater technological risk warrant greater government participation. Eighteen such projects have been approved so far.

The office gives 100% support for research at academic labs to provide fundamental information for industrial development. "Preindustrial R&D" projects also can be supported through a newly created joint fund between the office and the universities, until the projects reach the stage of industrial interest. And up to 30% support is given industrial R&D projects designed to replace imported products with locally produced goods of equal or better quality.

Firms that are successful in developing a commercial product from a supported R&D project return the original grant amount plus interest to the office's research fund by paying a royalty of 1% on sales of the product. (National projects pay 2% royalties.)

Two constraints that Israel faces in developing innovative products for export are the small local market—which can serve at best as a "piloting market" for most innovative products—and the relatively small size of Israeli firms compared to huge companies they must compete with in foreign markets.

However, Lavie notes, small firms often have the advantages of technical resourcefulness, flexibility, and quick response to test results and market opportunities, and Israel tries to encourage this. Lavie's office has enabled even very small firms to carry out R&D. Such support also shares and thus lessens the risk that an R&D investment, if unsuccessful, will wipe out a small firm.

For example, he cites three small Israeli firms producing computerized numerical control equipment, employing only 20 to 40 people each. The firms already have exports of $1 million to $3 million a year each, and are increasing exports at the rate of 300% a year.

Another small firm with some 60 employees, Dexter Chemical Corp. (a subsidiary of a small U.S. firm of the same name based in the Bronx), is a multimillion-dollar exporter of auxiliary chemicals for textile processing, and is one of seven winners of the most recent annual Israeli export prizes. Breaking into a new field, the Israeli firm now is doing R&D on pheromones for possible control of a cotton pest and other insects. Six pheromones look most promising.

However, Lavie points out, it is very difficult for small firms to learn about and to penetrate markets abroad. Israel does not want just to sell the rights to its innovations to foreign firms, but rather to have at least the first production plant built in Israel. So cooperation with other countries—joint R&D, joint ventures, investments, and other relationships—is seen as extremely important, particularly for the marketing tools it supplies. The Ministry of Industry, Trade & Tourism tries to promote such cooperation through loans, grants, and other incentives. Another inducement to non-European firms is duty-free entry for Israeli-made industrial products to the European Common Market under an agreement in effect since 1977.

Indeed, the pheromone project has become a joint venture with a large

Foundation promotes joint R&D by U.S., Israeli firms

C&EN staff photo

Mlavsky: technological bargains

"There are some real technological bargains in Israel—real talent, capabilities, and a lot of ambition. So our funding is not a handout—it's a vehicle for supporting programs of mutual benefit."

In this enthusiastic way, A. I. "Eddie" Mlavsky describes his work as the executive director of the Israel-U.S. Binational Industrial R&D Foundation (BIRD F) to a visitor to his office on the outskirts of Tel Aviv. In days of lagging U.S. industrial innovation and productivity, there is special interest in this unique attempt by the U.S. and a foreign government to promote joint R&D by firms in their countries.

"There are some very sophisticated companies in Israel, but there are also some very small companies just starting up," Mlavsky notes. "I'm an old Rte. 128 man, myself," he says, citing the small science-based firms that started in the 1950's and 1960's along Boston's suburban belt highway. (Mlavsky is on leave from the executive vice presidency of Mobil Tyco Solar Energy Corp., located near Rte. 128 in Waltham, Mass., which is developing photovoltaic cells.) "And this reminds me of it—a lot of young guys with concepts and daring, some not too knowledgeable on marketing" or on how to commercialize a product. "So we ask people for their commercialization plan, as well as their technological startup plan. It's a good disciplinary measure for companies."

BIRD F was formally established in 1977, he points out, but only started sponsoring projects about a year ago. It is the only institution of its kind between the U.S. and another country—and probably the only one between any two countries—explain Mlavsky and David A. Guberman, a special assistant to assistant secretary of Commerce Jordan J. Baruch, who monitors BIRD F for the Commerce Department. (The U.S. has had indications of interest in similar programs from other countries, such as Egypt and India, Guberman says, but is waiting for more experience with Israel before deciding on additional programs.)

BIRD F was started with an endowment of $60 million, approximately half from each country's government, and its board consists of three senior government officials from each country. The annual income on the endowment, about $2.6 million in the past year, is used to aid projects between U.S. and Israeli for-profit firms, typically paying 50% of costs up to a maximum of $250,000 a year, for up to three years. One-year awards of up to $100,000 are also given for testing technical and market feasibility.

Support can cover all stages, from lab exploratory research to test marketing, as long as R&D is the main component. Recipients agree to pay BIRD F if their project is commercially successful. Proprietary information is kept confidential, and any patents belong to the firms involved, with a royalty going to BIRD F.

The foundation expects to have 20 projects under way by the end of the year, and its board is exploring ways of increasing its funding capabilities. This is especially important because the original $60 million endowment has shrunk to less than $40 million through devaluations of the Israeli currency.

Current projects include medical electronics, advanced communication equipment, computer software, solar energy (developing a system for generation of industrial process heat and steam), and agrotechnology (for example, computerized irrigation systems)—in all of which Israel has state-of-the-art capabilities. A project under consideration involves pharmaceutical development.

Under one project, clinical testing is being done on an ovutimer, a device pinpointing the exact day of a woman's ovulation by measuring the viscosity of her vaginal mucus. This involves Elron-Iscar Biomedical Instruments Ltd. of Haifa and Ovutime Inc. of Brookline, Mass. And a joint project by Israel Chemicals Ltd. of Tel Aviv and General Refractories Inc. of Philadelphia is developing a low-energy-consuming process for making high-purity magnesium oxide (periclase) from Dead Sea salts for use in refractory bricks to line steelmaking furnaces.

One problem is that the foundation is not yet well known in the U.S., Mlavsky says. He especially hopes to attract more interest from medium- and smaller-sized firms, with annual sales of a few million dollars to $100 million. He considers such firms most suitable for joint ventures: Their size is closer to that of Israeli firms; participation in a BIRD F project can significantly increase the R&D funding, technology, and talent available to them; and it can greatly enhance their opportunities for foreign sales.

U.S. chemical firm not previously active in Israel, whose name is being withheld from publication at present. The Israeli side will continue R&D and will produce the pheromone; the U.S. chemical firm will explore marketing and the logistics and equipment for aerial spraying over large areas.

Overall, more than 150 foreign firms cooperate in various ways with Israeli firms, including more than 20 joint ventures. Among them are 20 of the "*Fortune* 500" U.S. corporations. U.S. chemical and chemical-related firms include Monsanto, Pennwalt, Baxter Travenol Laboratories, Witco, Miles Laboratories, Revlon, General Refractories Co., Sigma-Aldrich Corp., Philipp Brothers Chemicals, and Belco Petroleum Corp.

In addition, about 20 projects involving joint R&D by U.S. and Israeli firms will be funded by the end of this year by the Israel-U.S. Binational Industrial R&D Foundation (BIRD F). Establishment of similar foundations between Israel and other countries is being discussed. And a new company has been set up in the U.K. to promote cooperation between Israel and the U.K. and other European and Commonwealth countries. (There also are U.S.-Israel foundations to promote joint nonindustrial research and agricultural research—the U.S.-Israel Binational Science Foundation and the U.S.-Israel Binational Agricultural R&D Foundation.)

Whenever the subject arises of cooperation and investment by foreign firms in Israel, a question inevitably follows: How effective is the Arab boycott of Israel and of firms that have links to Israel?

There is "no doubt," acknowledge Lavie and A. I. Mlavsky, executive director of BIRD F, that some U.S. and European firms are inhibited by fear of the Arab boycott from starting ties with Israeli companies. (U.S. firms will not admit this, particularly since some forms of cooperation with

Inorganics the strong point of Israel's chemical industry

Israel's chemical industry is now developing briskly. Its strong point so far is inorganics, according to David M. Vofsi, head of the Center for Industrial Research at Weizmann Institute. Vofsi took a leave of absence in 1974–75 to serve for a year as director of research at Makhteshim Chemical Works Ltd. in Beersheba, and keeps in close touch with the chemical industry.

Dead Sea Works Ltd. exports about 1.2 million metric tons a year of potash, Vofsi notes, and is stepping up its capacity to 2 million (targeted for completion by the end of 1981). About 2.5 million metric tons of enriched phosphate rock are exported annually. And some 60,000 metric tons a year of bromine are produced from the Dead Sea, with $70 million in exports of bromine and bromine compounds. Israel is second to the U.S. in world bromine production.

One focus of considerable effort now at Makhteshim and other firms is programs to convert this large bromine supply into upgraded products, such as bromostyrene. A bromination process developed at Makhteshim, which Vofsi worked on, has passed the pilot-plant stage. A decision is imminent on construction of a plant to make thousands of metric tons a year of bromostyrene.

The Dead Sea also is the source (by conversion of magnesium chloride to magnesium oxide) of 50,000 metric tons a year of high-grade periclase for use in refractories, such as steel mill furnace brick linings. Essentially all of this production is exported, yielding $25 million a year.

There are two large producers of herbicides, fungicides, and insecticides—Makhteshim and Agan Chemical Manufacturers Ltd.—both belonging to Koor Chemicals Ltd., the chemical division of Israel's large industrial conglomerate, Koor Industries. The two firms export about 80% of their production, including to the U.S.

Israel's pharmaceutical industry is gaining momentum now, Vofsi adds. It is on the verge of converting from a generic, "me-too" type of industry—which concentrated on developing a better process or product for already existing drugs—to a maker of more sophisticated and original products of its own. The drawback, of course, he notes, is the great expense and long time to develop and test new drugs, especially to meet U.S. regulatory requirements.

Israel has almost no local petroleum and gas, and so its petrochemical industry is greatly affected by soaring world oil prices. It has a capacity of about 100,000 metric tons a year of polyvinyl chloride—at least 60% of which is exported—and makes a similar amount of low-density polyethylene. Israel also makes polystyrene, phenolic- and urea-formaldehyde resins, and polyesters for reinforced plastic.

C&EN staff photo

Vofsi: plastics from kibbutzim

In the synthetic fiber field, it makes the three most important basic fibers—nylon and nylon 66, polyterephthalate ester, and acrylics. It exports them only in the form of finished clothes. Israel does not make synthetic rubber, but imports and compounds it locally.

Interestingly, Vofsi observes, the center of the plastics fabricating industry is in Israeli kibbutzim (collective agricultural settlements). It is very appropriate because it is nonpolluting, does not require heavy investment, supplies jobs for older and handicapped people who cannot work in the fields, and is in some cases connected with agriculture. Among the products: highly sophisticated plastic irrigation components, plastic eyeglass lenses, and injection-molded plastic crates for gathering crops. Recently, Vofsi met with some kibbutz members, including a chemical engineer, to discuss possible production of contact lenses.

The Weizmann chemist stresses that Israel's future lies in developing the most sophisticated chemical areas—chemicals selling for $5000 to $50,000 or even more a metric ton—rather than trying to compete in low-priced chemicals, especially where Israel lacks raw materials. Thus he would focus on flame retardants, pesticides, pharmaceuticals, medical diagnostics, vaccines, biomedicals, and other specialty-type chemicals. As for Israel's bulk inorganic chemical products, he says, the future depends on the costs of transportation and of energy for processing. (For instance, a canal from the Mediterranean to the Dead Sea, recently approved in principle by the Israeli government, would produce hydroelectric power.)

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the boycott are against the law, notes Mlavsky.)

Many of the foreign firms that establish links do not want their names publicized because of commercial reasons as well as the Arab boycott, points out Philip K. Isaacs, chief technologist and coordinator of international R&D in Lavie's office. However, he continues, "I think it's significant that some of these companies, even though they say outright that they don't want their names used, come anyway."

In summary, stresses Lavie, "We don't see that this [the boycott] is really a main obstacle when we speak of technology. But this is an obstacle, and we shouldn't underestimate it."

R&D supported by Lavie's office covers a wide variety of fields, including agrotechnology, water desalination, electronics and medical electronics, communications systems, minicomputers, solar collectors, and textile machinery. Chemical-related projects take a major share, numbering 45% of total industrial R&D projects in Israeli fiscal year 1978–79 (beginning April 1, 1978) and receiving 32% of the money. Only electronics got more funding, 48% of the total. (These figures do not include national projects, BIRD F projects, or long-range projects at academic labs, which also have a high chemical component.)

Chemical R&D projects include work on: new pesticides; fire retardants; nitrogen-phosphorus-potassium fertilizers (Israel has sizable resources of phosphates and potassium); new compounds from bromine and magnesium; anticorrosion pigments; ceramic products; lubricant additives; pharmaceuticals, including development of new medicines based on plant, animal, and marine sources; clinical chemical diagnostic kits, particularly radioimmunoassay kits; fine chemicals for research; enzymes for food and other industrial processes; and preparation of a food sweetener and of aromatic and dye additives from citrus fruit peels.

Israel's chemical industry already contributes almost half of the country's industrial exports based on local R&D. Total chemical, rubber, plastics, and oil products exports reached $726 million in 1979, up 38% from 1978. The industry plans to double chemical exports by 1988.

The push for industrial R&D and science-based, export-focused industry in Israel already has produced several success stories frequently cited as models for future development. One is the Haifa-based Elron Electronic Industries group of companies, founded in 1957 as a "garage operation," which now has more than

3000 employees, including about 800 engineers and scientists. The founder and president, Uzia Galil—sometimes called the founder of science-based industry in Israel—says he expects more than $90 million in sales this year (compared to $70 million last year).

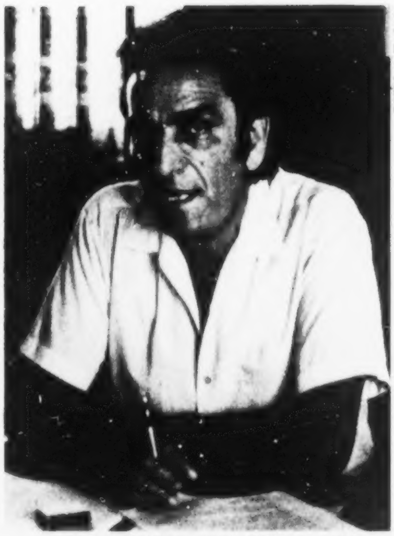
The Elron group has developed computer equipment and systems, electronics, and medical and nuclear medical instruments (including a computerized tomography system), and is now moving into fiber-optics and orthopedic implants. The firm has joint ventures with several foreign companies.

A second firm is Ames-Yissum Ltd., founded in 1968 as a joint venture by Miles Laboratories of the U.S. and Hebrew University's Yissum Research Development Co. The idea was to commercialize the results of university research, particularly development of medical diagnostic systems.

Ames-Yissum, located in the university's industrial park for science-based industry in Jerusalem, currently makes 10 different thyroid function diagnostic test kits, plus a number of other tests. Ninety-seven per cent of production was exported last year and sales were $2.3 million (50% in the U.S.). The firm now is introducing thyroid function tests using new chromatography tubes and packings it has developed. It also is working on virology tests, and on nonradioactive alternatives to its current radioimmunoassay systems.

A third firm is Ormat Turbines Ltd., established in 1965, which has sold more than 3000 low-temperature Rankine cycle turbines all over the world, particularly for use in remote locations where low-maintenance electrical generating equipment is needed. For example, 122 turbines are being used on the Trans-Alaska Pipeline for telemetry and remote gate valves. Sales in 1979 were about $10 million. The firm also makes solar pumping systems and systems for producing power from industrial low-temperature waste heat and other low-grade heat sources.

Ormat now is testing a solar pond method of electricity production in a 150-kw pilot unit at Ein Bokek on the Dead Sea shore. According to the method, developed originally at Scientific Research Foundation in Jerusalem, salt is dissolved in the 7000-sq-m pond, building a density gradient rising in concentration from top to bottom. If the density gradient is sufficiently great, solar rays can penetrate the pond and heat the lower layers of water to about 80° to 100° C without any convection. The top, cooler layers act as an insulator, as long as the pond is not stirred. Hot water then can be piped from the bottom, without disturbing the concentration gradient, into a Rankine cycle turbine using a low-boiling liquid, and electricity generated.


C&EN staff photo

Lavie: righting inverted pyramid

Use of the solar pond has two advantages: It is a large-scale, cheap solar collector without glass or metal; and it also stores the heat for use when needed, night or day. All the system needs is water, salt, sunshine, and available land. Ormat says the cost per kilowatt hour will be competitive with conventional and nuclear systems.

The firm plans to start up a 5-Mw unit next year—the first module of a possible 20-Mw or larger system. And it is conducting feasibility studies related to building a solar pond power-generating demonstration plant of 5 Mw in California, under contract to Southern California Edison Co.

As Israel's academic institutions have shifted to more applied research, they have undertaken a number of steps promoting their efforts. These include strengthening central offices to coordinate, administer, and help seek outside R&D funding; creating centers to bring together scientists from different departments for work on specific interdisciplinary problems (such as energy, the environment, drug research, or genetic engineering); and building up departments in applied science and technology (such as Hebrew University's School of Applied Science & Technology, and its component Casali Institute of Applied Chemistry).

The efforts also include infusion of more applied research into regular academic departments, establishment of companies to deal with industrial development of research findings, and inauguration of nearby industrial parks specifically for science-based industry, including spinoffs from academic research (inspired by the example of Boston's Rte. 128). Ben-Gurion University of the Negev particularly has taken on the goal of aiding development of the Negev, Israel's southern, largely desert region.

Questions are raised about how industrially oriented research should be done in an academic framework, and how industrial it should get. Different arrangements are being tried at different institutions. And one serious problem, according to several sources (others deny it), is that Israeli academic scientists who do applied research are not rewarded with pay and promotions equally with those following the standard basic research-journal publication route.

Who's Who in Israeli chemical industry

The largest chemical conglomerate in Israel is Israel Chemicals Ltd. (ICL), owned by the Israeli government. Active primarily in inorganic chemicals, firms in this group include the Dead Sea Works Ltd., Dead Sea Bromine Ltd., Bromine Compounds Ltd., Negev Phosphates Ltd., Fertilizers & Chemicals Ltd., and Dead Sea Periclase Ltd. Besides ICL, also active in inorganics and fertilizers derived from potash and phosphates is Haifa Chemicals Ltd.

Koor Chemicals Ltd. is another conglomerate. It includes, among others, Makhteshim Chemical Works Ltd. and Agan Chemical Manufacturers Ltd., which make crop protection products and chemicals for plastics and photographic industries. Another chemical group is the Dor-Carmel Group, which produces methanol, formaldehyde solutions, hydrogen, plastic molding compounds, resins, glues, and salt.

In the petrochemical area, there is Israel Petrochemical Enterprises Ltd., which makes polyethylene, carbon black, and polystyrene. Electrochemical Industries (Frutarom) Ltd. makes chlorine and caustic soda, polyvinyl chloride, and other chemicals, and its Frutarom division produces aroma chemicals, citrus oils, flavoring essences, and perfume fragrances. And two major producers of pharmaceuticals and fine chemicals are Teva Pharmaceutical Industries Ltd. and Abic Ltd.

Former Israeli president, returned to chemistry, surveys science and society

A unique vantage point on science and society in Israel and in the world has been gained by Ephraim Katchalski-Katzir. For 24 years head of the Department of Biophysics at Weizmann Institute of Science, Katzir was elected in 1973 to a five-year term as president of Israel—a nonpolitical and largely ceremonial office, but one important in promoting national values and unity.

Katzir, 64, has done pioneering work on synthetic polyamino acids and their use as protein models and on immobilized enzymes, and has won many international honors. He has been a central influence in shaping Israeli science and science policy, including three years as chief scientist at the Ministry of Defense. On becoming president, he changed his name, Katchalski, to the Hebrew name Katzir. He has now returned to full-time scientific work, and was interviewed by C&EN at Weizmann Institute.

Katzir (right) and Israeli foreign minister Shamir talk with Anwar Sadat

What role can a small country like Israel play in world science, considering its limitations in size and resources? "As far as basic research goes, our priority as a small nation should be to try to make original contributions," says Katzir. "It's more difficult for us to compete with big nations and with big centers of science in an area where there is rapid development and in which many scientists participate. We should be aware of all these areas and know the ideas and techniques," he adds. But Israeli scientists should avoid just jumping on the bandwagon and doing what is in fashion.

Another contribution that Israeli scientists can make to world science, Katzir believes, is bringing traditional Jewish values and ideals—many of them now embodied in the Judeo-Christian tradition—to consideration of moral and ethical questions involving science. One case in which Israeli scientists have had influence, he observes, is in helping to focus the attention of the world scientific community on Soviet mistreatment of some Soviet scientists, and on Soviet bars to free scientific travel and exchange.

The former Israeli president is quite pleased with, but also critical of, the development of science and technology in Israel. On the one hand, he says, Israel has accomplished a great deal in its basic scientific research and higher education, and the efforts have "paid off in many ways"—in defense, agriculture, metallurgy, electronics, small computers, and other areas.

In this, he believes, Israel is implementing the ideals and values of its founders. "For the last 2000 years, Jews have respected intellectual and spiritual activities. As a result of this type of activity, they were able to retain their integrity as a nation."

On the other hand, Katzir says, "I think that we have overemphasized basic research," at the expense of applied and industrial research. "There were times when most of our scientists were dealing with basic research."

In 1968 Katzir headed an advisory committee that issued an influential report—named after him "the Katchalski Report"—urging the Israeli government to step up efforts in applied and industrial research (without reducing basic research), and to reorganize its R&D activities. This resulted in establishment of chief scientists' offices in a number of government ministries to coordinate and support R&D in their respective areas, including industry, defense, agriculture, health, and energy.

The balance now has shifted so that about half of all Israeli civilian R&D funding is in applied areas, he notes. He says that "we're going in the right direction," and recommends a goal of 60% applied and 40% basic research.

However, he believes, there is now a threat of going too far in the opposite direction. Many Israeli government officials and political leaders consider the current amount of basic research "a luxury" Israel cannot afford with all its other pressing needs. Some political leaders suggest that it would be better to deal with Israel's social problems, by spending more money on kindergartens and less on research institutions.

However, Katzir emphasizes—"and this is what I tell all our ministers and Prime Minister"—that increasing applied R&D should by no means involve reducing basic research. "We'll never have applied research of high standards without having good basic research."

Another problem that concerns Katzir and other Israeli scientists, such as Dov Frohman-Bentchkowsky, director of the School of Applied Science & Technology at Hebrew University, is insufficient national science planning and coordination, and inadequate seeking of scientific advice in making government decisions. There is no central science adviser to the Prime Minister and cabinet, such as the White House has, and individual ministries vary in their solicitation of scientific opinion.

Individual ministries give R&D funds to industry, agriculture, or other areas independently, "without interaction or coordination," notes Frohman-Bentchkowsky. And there is no coordination by such ministries with the Ministry of Education & Culture on manpower needs.

Katzir believes that one solution is a proposal now under consideration to set up a committee of four or five ministers to deal with all R&D areas of general national importance, such as energy, water supplies, and manpower. He also favors establishment of a central science adviser to the government. And he hopes to renew, within the framework of the National Council for R&D, a group of scientists and engineers he organized while president to identify problems deserving national priority and advise the government.

For a long time, Katzir says, Israeli scientists and engineers have not concerned themselves sufficiently—or often at all—with the problems and needs of Israeli society. This situation is gradually changing, he adds.

However, he believes, this is a general problem all over the world caused by too narrow training of scientists and engineers. Teachers should include the impact on or importance to society of whatever material, process, or theory they teach, he stresses.

Science provides tools that change the lives of individuals and nations in far-reaching ways, the Weizmann chemist notes. Scientists understand better than laymen the possibilities and dangers of these tools. "So they are responsible as a group," and must be ready to advise society on what should be done and not be done.

"This does not mean that every scientist should be involved in social and political activities," he adds. "And they should not take over the function of politicians."

Reflecting on his experience as president, Katzir observes that for a while politics was "a new and somewhat bewildering world." But in the end he developed much more respect for politicians and their problems and accomplishments.

"Very often scientists or professional people underestimate the role of politicians in society," he stresses. "A scientist doesn't worry whether his solution to a problem is liked by people or not. Who cares? If it's the right solution, that's that.

"But for the politician, it's not enough to sit in his room and find the right solution. He has to find not the *optimal* solution, but a solution that will satisfy the people with whom he's dealing, who will be able to follow him."

Ironically, Katzir acknowledges, at a time when Israel is trying to build up applied R&D and science-based industry, there are three contrary phenomena: an anti-intellectual strain in Israeli society, a "flight from science" among Israeli youth, and a "brain drain" of scientists and engineers leaving Israel.

A number of observers have pointed to the existence of an anti-intellectual streak in Israel, which one might expect in a developing, somewhat rough-and-ready society that often trusts action more than words (similar, perhaps, to U.S. frontier traditions). Katzir agrees that there is such a streak. "It is always strengthened when the economic and social situation is bad [as it is now], because then people look where to cut the budget. And they always look with suspicion on people that don't produce something that one can sell."

However, he does not consider this a serious threat, because of two counterforces: The general tradition of respect for intellectual activities is "still very, very strong"; and R&D and higher education have so obviously helped to promote Israel's development.

By all accounts, Israeli youth is now in the midst of what one prominent scientist calls "a flight from science." In the past, science had high prestige and glamor for Israeli youth, but university science enrollments have generally dropped greatly in the past few years.

Katzir and other Israeli scientists cite a number of reasons for this phenomenon. For one, the wave of disenchantment with science and the anti-intellectualism that hit U.S. and European youth in the 1960's reached Israel, aided by disillusionment following the traumatic 1973 Yom Kippur War.

More important, job opportunities have declined and the pay of scientists is often relatively low. Basic research and teaching positions have closed up, but there apparently will be a gap of several years before new industrial R&D spots develop in sufficient number, level, and prestige. And Israel's small size means that it takes only a few scientists to saturate a specialized area.

Another and related problem is a growing "brain drain" of young Israeli scientists and engineers going abroad for graduate work or postdoctoral training and staying there. (In the past, Israel enjoyed a "brain gain," with a net influx of scientific talent.)

This "very serious problem" greatly concerns Katzir and other Israeli scientific leaders. "Good manpower, highly trained and creative people, is our main raw material in building up the country."

The only way to deal with this problem, Katzir notes, is to increase Israel's absorptive capacity by building up industry based on Israel's raw materials (such as Dead Sea salts and phosphates) and on know-how (particularly sophisticated, science-based industry). For example, when computer and electronics industries began in Israel a few years ago, Israeli experts who previously could not find suitable opportunities in Israel were attracted back. (Indeed, Frohman-Bentchkowsky views the U.S. as a "reservoir" for overflow of Israeli scientists who can come back, enriched in training and experience, to work in areas that will be important in five or 10 years.)

Part of Katzir's current scientific efforts, split between Weizmann Institute and Tel Aviv University, are expected to help increase scientific opportunities in Israel. At Tel Aviv, he is establishing a center for biotechnology, which will include work in fermentation, genetic engineering, and immobilized enzymes. He sees bright commercial potential for Israel in biotechnology. And at Weizmann, he is conducting basic research in three areas—structural fluctuations in biopolymers, the effects on living cells of modifying their membranes, and transport of oligomers and polymers into cells.

Israeli academic labs have developed a number of ideas that are arousing commercial interest, in some cases from foreign firms. For example, Yeda R&D Co., which carries out industrial applications of Weizmann Institute research, has formed a joint venture with Ares Co. of Switzerland, called Inter-Yeda Co. This firm is slated to start this summer to make fibroblast interferon by tissue culture on newborn human foreskins (using Israeli circumcisions as a source). There are also agreements with foreign firms for R&D on possible interferon production by several other methods, including use of recombinant DNA techniques.

Moreover, Yeda has a contract with Miles Laboratories for R&D on preparation of a thymus hormone, thymic humoral factor (THF), first isolated and identified by Weizmann scientist Nathan Trainin. Miles has invested more than $1 million a year for three years for work, mostly in Israel, focusing on production of more material and clinical tests. The hope is to use THF for treatment of diseases characterized by deficient immune mechanisms.

These and other Yeda projects fall into the area of biotechnology, notes Aharon Meytahl, managing director of Yeda. Some U.S. financial analysts believe biotechnology will take off in the next 20 years as computers or semiconductors have, he points out. "New biological materials like interferon will become the electronic chips of the future," he suggests. So Israel and Weizmann Institute are well positioned in the life sciences, he believes. Furthermore, he says, Yeda is now negotiating with some financial institutions about establishing a sizable company to work in biotechnology.

Another Israeli application of biotechnology involves experiments with algae. Koor Food Ltd. of Haifa, for example, has been licensed by Yeda to commercialize work begun by Weizmann scientists on a red single-cell organism, *Dunaliella bardawil*, that thrives in saline ponds. It produces about 40% of its dry weight as glycerol, and up to 8% beta-carotene. The residue then provides high-protein meal, and eventually may provide other biochemicals. Koor is building a pilot project—5 acres of ponds—near Eilat to test the process.

Another algal application is under development at the Technion in Haifa. This is a high-rate algal system for combined wastewater treatment and protein production, developed by a team led by Gedaliah Shelef. Algal use for sewage treatment also is being studied at other Israeli institutions.

A third algal pond project is being done, of all places, in the heart of Israel's Negev Desert at Sdeh Boker, where Ben-Gurion University has its Jacob Blaustein Institute for Desert Research. The idea, according to Aharon Abelovich of the Applied Algology Unit, is to use brackish water ponds on arid land to raise algae as a protein source for animals and make this the basis of desert agriculture.

Abelovich uses a filamentous blue-green alga, Spirulina, which can stand high salinity (up to 10%). The system is a very efficient way of "harvesting light"—solar energy conversion—producing 8 kg dry weight per day on 400 sq m of ponds, two thirds of this protein. The possibility of extracting valuable chemicals from the product, as with Dunaliella, also will be tested. Several firms show commercial interest. (Other countries also are working on this alga, which has been used as food by tribes along Africa's Lake Chad and by ancient Aztecs in Mexico.)

Solar research in general, desalination, biomedical devices and instruments, and development of Israel's oil shale deposits are other active R&D fields. For example, in the solar area Ormat is preparing field tests of novel polycrystalline photoelectrochemical cells with liquid electrolyte developed at Weizmann Institute by Joost Manassen, Gary Hodes, and David Cahen, which have attracted wide commercial interest. And Renata Reisfeld of the Inorganic Chemistry Department at Hebrew University is cooperating with the U.S. Department of Energy and some U.S. firms in research on use of planar fluorescent concentrators to multiply the intensity of light falling on solar photovoltaic cells.

As Israel looks to future development of its science and technology and science-based industry, it faces many problems. One, according to Uzia Galil and David M. Vofsi, head of the Center for Industrial Research at Weizmann Institute, is insufficient entrepreneurial spirit. "To set up new industry, you need to take risks. People here are not willing to take risks," Vofsi notes. There are very few examples, he points out, of scientists who have left the laboratory to set up their own firms to develop their ideas.

Insufficient attention to the environmental effects of industrial development is another problem area. For example, Samuel J. Meltz of the Institute of Desert Research notes that there are plans to build a major center of chemical and petrochemical industry at Ramat Hovav, just 12 km south of Beersheba. Already, he notes, evaporative containing ponds

Israel-Egypt science ties: don't push too fast

Certainly the most dramatic event during chemist Ephraim Katchalski-Katzir's service as president of Israel was the visit to Jerusalem in 1977 of President Anwar Sadat of Egypt—the first such contact between Arabs and Israelis in three decades of conflict. As head of state, Katzir welcomed Sadat to Israel and rode beside him to Jerusalem, and he has since met twice more with the Egyptian leader and his advisers.

One particular question he discussed with Sadat was: Is Israeli-Egyptian scientific and technological cooperation possible, and how can it help to bring peace to the Middle East?

According to Katzir, Sadat's response in essence was, "Look, I don't understand science, but I know that it is important. In principle, I'll promote cooperation. But let's not push it too fast."

Thus, so far Israeli-Egyptian scientific relations have been unofficial and low key, involving get-acquainted private visits by a number of Israeli scientists to Egypt, conversations at international conferences in third countries, and a few visits by Egyptian officials to Israeli scientific institutions. For example, chemist Yael Allingham of Weizmann Institute made a private visit to the National Research Center in Cairo last May. There, she held "very open" discussions with some 15 senior scientists on parallel work she and they are doing on marine antifouling paints, environmental pollution, and corrosion.

Both sides have the same antifouling problems in the Mediterranean Sea, she notes. And both sides expressed hope of cooperating in the near future. The Egyptians said, "Just wait a little longer—we'll have a little more peace, and then we can have cooperation."

The general impression, therefore, is that of a "one-sided love affair," as one Israeli observer puts it, with Israeli scientists eager to start (and offering some specific proposals), while the Egyptians want a "gradual process." Apparently, establishment of scientific ties will require improved political relations between the two governments.

There are several scientific areas in which the two nations share common problems because of their common location and climate, and in which cooperation might be fruitful—for instance, agriculture, medicine, solar energy, oceanography, and desert research.

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Galil: more entrepreneurs needed

for effluents from plants on site are leaking, and chemicals are leaching laterally into a wadi (dry riverbed) nearby.

Moreover, Meltz points out, a national toxic waste disposal site has been started in the vicinity. His group is hoping to do a baseline environmental assessment before things get much further along.

No one can visit Israel without becoming forcibly aware of the tremendous burden that defense efforts place on Israeli society—in diversion of resources and manpower, in long reserve duty for able-bodied males, or in the eternal vigilance that is required to prevent a terrorist bomb from exploding in a bus, shop, or street.

This undoubtedly has restraining effects on development of science and technology, and science-based industry. However, several Israeli scientists point out that the effects are far from being all negative. For instance, Katzir and Pelah, both chemists long associated with Israel's defense R&D establishment, say that "an extraordinarily good group" of scientists has been built up there. And this has led to creation and stimulation of several sophisticated civilian industries, both through military contracts and spinoffs to civilian life of scientists and know-how.

So of these and many other Israeli difficulties that sometimes seem insurmountable, Mlavsky says, "It's hard to be competitive, but somehow the Israelis manage to be competitive. They're unrealistic in not being willing to accept the odds against them. But that's why they've achieved what they have." ☐

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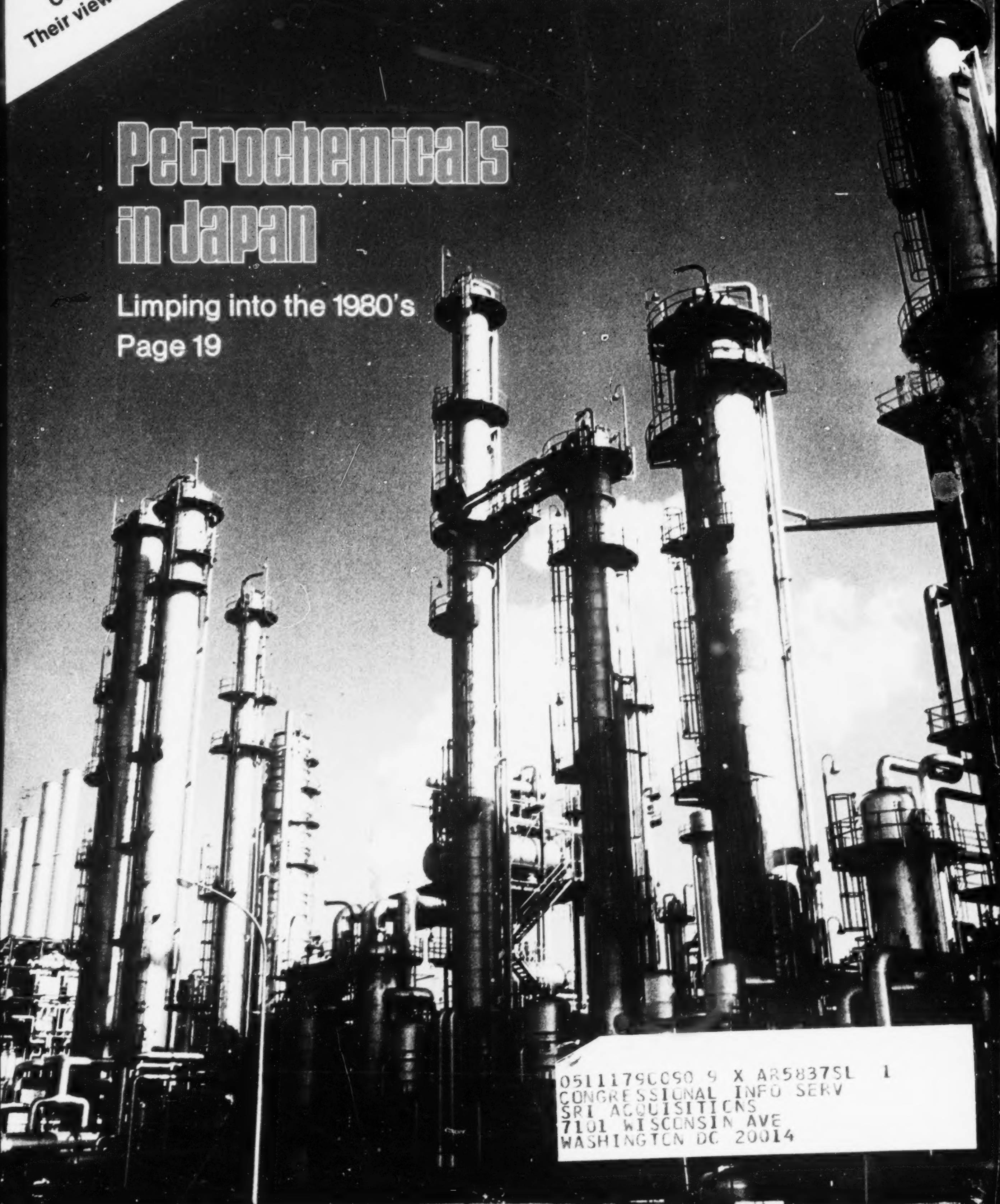

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Petrochemicals in Japan face troubled future

Skyrocketing raw materials costs and fierce competition among firms lie behind poor profitability that continues to plague Japanese producers

Earl V. Anderson
C&EN, New York

Petrochemical industry executives in Japan are looking ahead to the future and finding that the future is now.

Since late spring, the industry has fallen upon rough times. Production has been dropping and continues to drop. Inventories are building up. The consequences soon will start showing up in less-than-attractive profit and loss statements.

What is happening to Japan's petrochemical industry, and what has been happening for the past four or five months, is a startling reversal of the production records and profit improvements that Japanese petrochemical companies had been racking up over the previous 18 months. Welcome changes for the better started sifting through the entire industrial structure starting in late 1978. The improvements continued throughout 1979.

Industry leaders welcomed 1980 with confidence and optimism, although, to be sure, some of that optimism was guarded. For the first few months of the year, the optimism seemed justified.

Then, just as it seemed as if the Japanese petrochemical industry finally was overcoming the effects of the 1973 oil shock, its fortunes took a nosedive. It soon became apparent that the effects of that seven-year-old oil crisis are still there. It also has become apparent that the production records set during those heady days of late 1978 and 1979 weren't really indicative of true demand.

The outlook for the remainder of the calendar year and for the fiscal year, which for most Japanese companies ends in March 1981, isn't particularly encouraging. There now are very few optimists to be found in the petrochemical industry's executive suites.

Whatever improvement, if any, that may come to Japan's petrochemical industry over the next three to six months will be gradual. And it will be slight. At press time, Japan was scheduled to unveil a new economic package designed to stimulate an economy that shows unmistakable signs of slowing down. Depending on what is in that package, it could help some. But most of Japan's petrochemical leaders are realistic enough to know that government's economic stimuli take time to filter down to their industry.

As a result, the next three to six months will be critical ones for the country's petrochemical industry. The problems that it faces and the way that it handles them will be watched carefully, because they will be the same problems the industry must solve over the next 10 to 15 years if it is to survive.

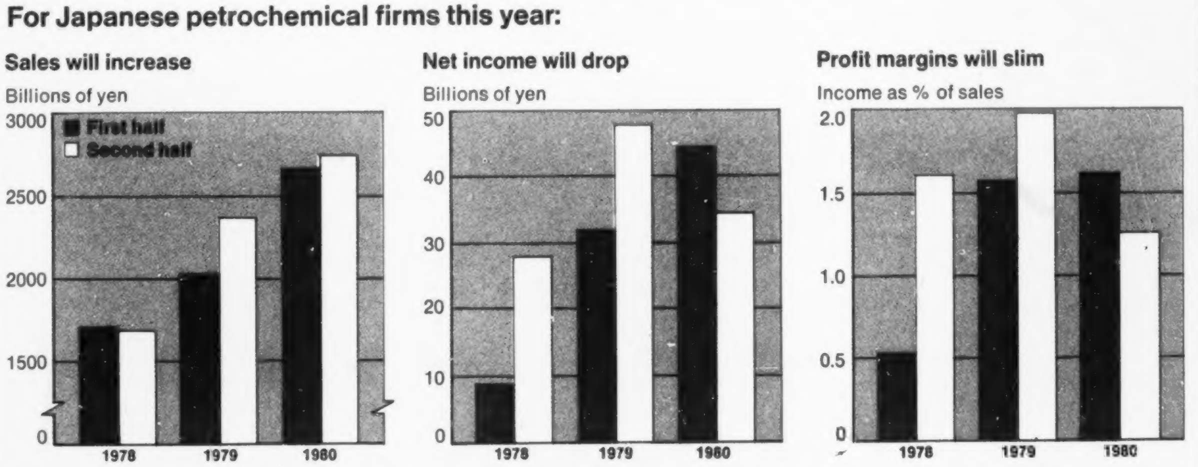
That is no exaggeration. More than one analysis of the petrochemical industry's future is laced with phrases such as "bracing itself for the arrival of a new era," "faced with the stark issues of survival," and "difficulties . . . threaten its very existence."

At the head of the problem list is profitability—or lack of it. Historically, Japanese petrochemical companies always have had slimmer profit margins than their U.S. or European counterparts.

Profit margins and profits took a quantum leap upward during late 1978 and 1979. Despite the improvement, however, a U.S. chief executive wouldn't find them much to brag about.

Now, even that recovery seems to be short-lived. It's all but certain that profits for most Japanese petrochemical companies will tumble in the second half of fiscal 1980.

Most of the industry's other prob-


For Japanese petrochemical firms this year:

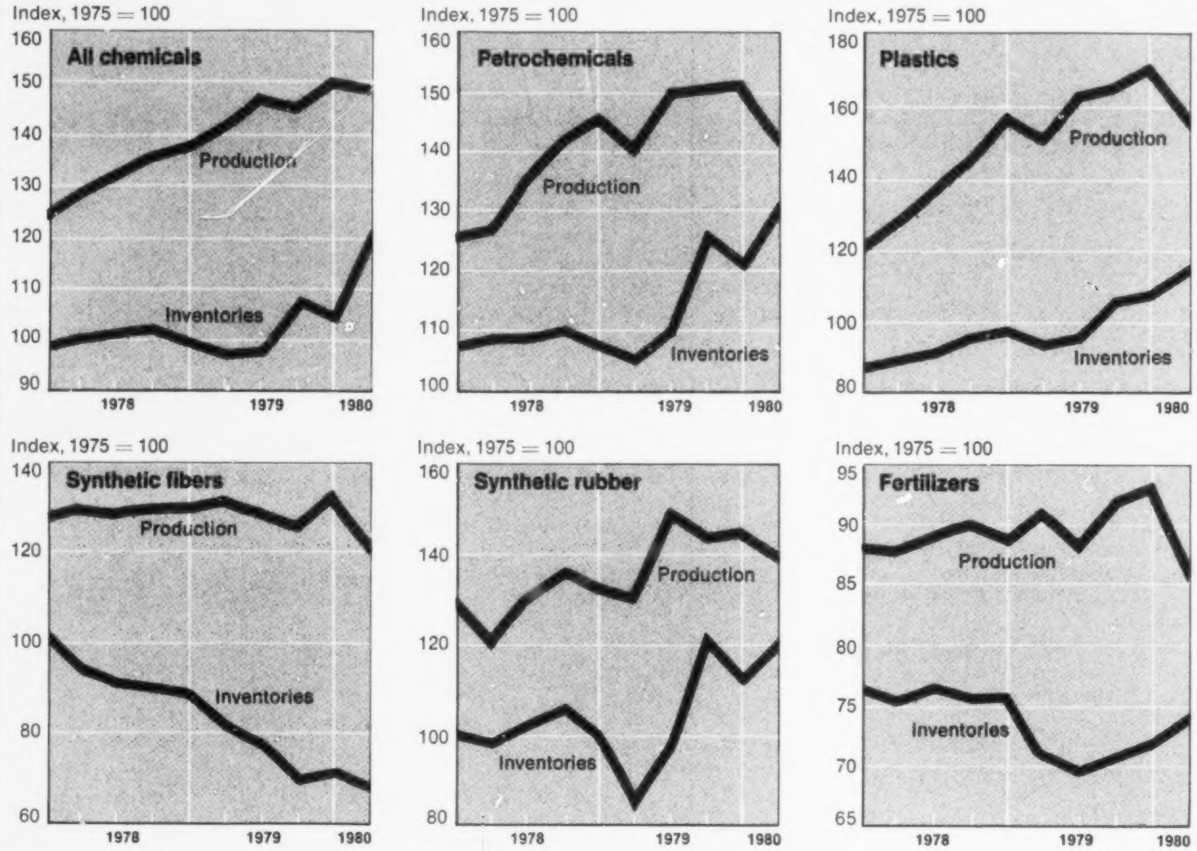
Sales will increase

Net income will drop

Profit margins will slim

Note: Six-month data are for fiscal years ending March 31. Based on results and estimates of 10 leading Japanese petrochemical companies—Mitsubishi Chemical Industries, Sumitomo Chemical, Asahi Chemical Industry, Toray Industries, Mitsui Toatsu Chemicals, Teijin, Showa Denko, Mitsubishi Petrochemical, Dainippon Ink & Chemicals, and Sekisui Chemical. **Source:** Toyo Keizai Shinposha

Japanese chemicals: Production is declining, inventories rising in most areas



Note: Second-quarter 1980 data are C&EN estimates. **Source:** Ministry of International Trade & Industry

lems are the rocks that weigh down profitability. Chief among them is raw material supply and price.

Japan's petrochemical industry is based primarily on naphtha, much of which is imported. That which is produced domestically relies on imported crude oil. And it is no secret that, until very recently, imported naphtha and crude prices have skyrocketed in Japan.

Although Japanese petrochemical companies have had to shoulder much higher raw material costs, they have had trouble passing those costs along to their customers. Even when they were able to make higher prices stick, the increases didn't keep pace with costs.

The reasons differ from time to time. On occasion, it's simply been a case of too much capacity and too little demand. Even when demand was there, prices didn't go up so much as they should have.

That's because, contrary to some popular opinion in the U.S., competition among Japanese petrochemical producers is fierce. The industry is made up of a large number of fairly small competitors.

Last year's sales of Mitsubishi Chemical Industries were about $2.5 billion. Now Mitsubishi is the largest petrochemical company in Japan, yet its sales last year pale alongside those of Hoechst's $15.6 billion, the $15 billion of Bayer and BASF, or Du Pont's $12.6 billion.

With many small competitors slugging it out in the marketplace, competition is bound to be fierce. Petrochemical prices reflect this ferocity. Many Japanese chemical companies routinely cut prices or refuse to raise them to grab a small additional slice of the market. Corporate profits in Japan's petrochemical industry testify to it.

Higher raw material costs are starting to take their toll on the industry's prowess in international trade. Japan's petrochemical industry has enjoyed a favorable balance of trade for many years. It still does, and probably always will.

But the task is becoming more difficult. U.S. companies, with their feedstock advantage, are squeezing Japanese petrochemical companies out of their cherished Southeast Asian market.

Meanwhile, new and formidable competition is springing up in Asia itself. Taiwan and the Republic of South Korea are on the road to self-sufficiency in petrochemicals. In several other Asian nations, petrochemical projects are being built. Meanwhile, additional contenders for international markets are shaping up in the oil-rich countries of the Middle East and in other developing nations as well.

While Japanese companies are finding it more difficult to export, they are finding it increasingly necessary to import. Through the first four months of the year, they imported almost $2 billion worth of chemicals, 28% more than during the same period last year. During the same period exports increased too, of course, but not so much.

As if these problems weren't enough to cope with, Japanese petrochemical companies face additional troubles at home. Land is extremely scarce in Japan. Most of the attractive industrial sites already have been exploited. To expand, or to replace old, inefficient plants with new ones, Japanese companies will have to employ scrap-and-build tactics on existing sites.

Now, just when Japan's petrochemical industry is facing one of its severest tests, it no longer can regard itself as one of government's favorite and coddled industries. There was a time when it was.

During the early stages of its growth, the industry received protection and support from the government and from financial circles as well. It received investment funds at low interest rates, special depreciation rates, and, in some cases, tax forgiveness. It received preferential treatment to obtain foreign technology.

All of these crutches have long since been taken away from the petrochemical industry in Japan. Says Hisashi Kurokawa, president of Mitsubishi Petrochemical, "The petrochemical industry, which was once lionized as a strategic industry, has come to be regarded as an industry that produces pollution as well as consumes a huge amount of energy."

Recently, Norishige Hasegawa, chairman of Sumitomo Chemical, is reported to have said, "MITI [Ministry of International Trade & Industry] claims that my industry is structurally depressed. That's not true. We are politically depressed."

Hasegawa's comment was made during negotiations between industry and government over naphtha prices. And if there is one overriding factor that is causing Japanese petrochemical companies to lose their competitive edge at home and abroad, it is naphtha—its supply and its price.

Starting in late 1976, as the world market price became more attractive vis-a-vis domestic naphtha, Japanese ethylene producers turned increasingly to imports. In less than a two-year period in 1977–78, imported naphtha's share of all the naphtha consumed in Japan rose from 34% to 40%.

Prices that Japanese petrochemical companies paid for imported naphtha bottomed out in the fall of 1978 at about 18,000 yen per kiloliter, then seemed to stabilize at about 21,000 to 24,000 yen per kiloliter (about \$84 to \$96). This still was some 20 to 25% less than domestic refiners were charging in Japan.

Then, says one Japanese chemical executive, "all hell broke loose." Prodded by the turbulence in Iran, naphtha prices on the spot market skyrocketed. Japanese naphtha importers were forced to accept several price increases in their long-term contracts.

The average price that Japanese petrochemical companies paid for their imported naphtha doubled last year. By year's end, they were paying about 50,000 yen per kiloliter or about \$40 per bbl.

For Japanese petrochemical companies, domestic naphtha had become less expensive than imported material, despite Japanese refiners' paying much higher prices for their imported crude. But domestic naphtha could supply only half of Japan's requirements. As a result, Japanese petrochemical companies were stuck with expensive imported naphtha.

The industry found itself locked into this uncomfortable naphtha situation just as it was about to take off on a production binge. Starting in the fourth quarter of 1978 and continuing through all of last year, output of most major petrochemicals soared in Japan.

In 1978, thanks to a surge in the third and fourth quarters, ethylene production hit 4.4 million metric tons, 10% higher than in 1978. It marked the first time that ethylene output in Japan topped 4 million metric tons since 1974. Last year, ethylene production jumped another 9% to a record 4.8 million metric tons. By the fourth quarter of 1979, ethylene producers were operating at close to a 5 million metric-ton annual rate.

In aromatics, the trend was the same. 1979 production of benzene was up 8%, toluene 7%, and xylenes 5%.

In fact, all along the petrochemical product chain, there were indications that Japanese petrochemical companies finally were starting to breathe the fresh air of recovery following a recession that started in 1975. Demand increased for most products. Output surged to meet the demand.

Overall, production of petrochemicals in Japan rose 10.4% last year. Plastics output led the pack with a 20% increase. Synthetic rubber production increased 8%. Only fibers and chemical fertilizer remained relatively static.

More important than its resurgence in production, the Japanese petrochemical industry was able to raise prices during this period—and make them stick.

This resurgence in prices was a welcome change for petrochemical companies. Throughout most of 1978, petrochemical prices declined for a combination of reasons. Negotiations between petrochemical companies and refiners over naphtha price were deadlocked for a long time. Customers, anticipating a drop in domestic naphtha prices, resisted industry attempts to raise prices.

Besides, demand wasn't particularly brisk at the time. It didn't start picking up until the latter part of the year. On the supply side, output from two new ethylene plants (one came on stream in the summer of 1977 and the other in the spring of 1978) had to compete for a share of a still stagnant market.

Until the round of price increases last year, prices on Japan's chemical market were so low—and so unprofitable—that they were known throughout the industry as "sunken prices." Last year's price increases lifted the industry out of the sunken price stage, but it still has a long way to go to achieve an adequate pricing structure.

Increased demand and higher prices did, however, enable Japanese chemical companies to improve their profit picture. In fiscal 1979, combined sales of the 10 largest Japanese chemical companies hit 4381 billion yen (about \$18.3 billion), which was a welcome 27% higher than the preceding year.

But sales alone don't tell the whole story. Starting in the second half of fiscal 1978 (that is, from September 1978 to March 1979), the net income of these 10 largest companies improved significantly. For instance, in the five previous fiscal half-years, their net income never exceeded 10.4 billion yen and had been as low as 4.3 billion yen.

However, in the second half of fiscal 1978, their net income jumped to 27.7 billion yen and it continued soaring to 31.9 billion and 47.5 billion in the first and second halves of fiscal 1979.

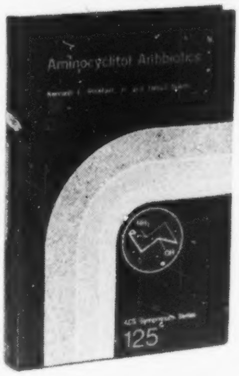
In all, net income of the top 10 Japanese chemical companies tripled in fiscal 1978 to 36.2 billion yen. It more than doubled again in the past fiscal year to 79.4 billion yen.

Along with this improvement in net income came an equally impressive improvement in profit margins. In fiscal 1976 and 1977, the profit margins of the 10 companies were about 0.3% and 0.4% of sales. In fiscal 1978, however, they were able to boost their profit margin to an average 1.05%. They raised it again last year to 1.81%, hardly an ecouraging figure compared to Dow's 8.5% or Du Pont's 7.5%, but a step in the right direction nonetheless.

Last year's performance of Sumitomo Chemical is typical of many chemical companies in Japan. In fiscal 1979 (which for this industry giant ended on Dec. 31), Sumitomo's sales increased 26.6% to 551 billion yen (\$2.3 billion). However, it managed to increase net income a whopping 18% to 11 billion yen (\$47 million).

In reality, the marketplace fortunes of Japanese petrochemical companies in 1979 are turning out to be an all-too-temporary mirage. Certainly, petrochemical demand was there in

Aminocyclitol Antibiotics



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1979 and the industry went all out to meet it. But industry leaders now realize that what they really were meeting was an increase in "false demand."

With naphtha prices and petrochemical prices rising rapidly, customers went on a purchasing binge to build up their inventories in anticipation of still higher prices to come.

At the beginning of this year, confidence still oozed out of petrochemical company boardrooms. And for the first few months of the year, developments seemed to justify that confidence.

During the first quarter of 1980, the petrochemical production index averaged 152.9 (1975 = 100). In April, it hit 153.9. Both are higher than the strong third and fourth quarters of 1979.

According to production indexes compiled by MITI, output of plastics, synthetic fibers, synthetic rubber, and chemical fertilizer in this year's first quarter all exceeded that of the previous quarter.

During that first quarter, Japan's ethylene producers managed to turn out 1.2 million metric tons of product, just shy of the 1.4 million metric tons produced in the previous quarter.

Shortly after that, however, the mirage disappeared and reality set in. Ethylene production, a reasonably good leading indicator of Japanese petrochemical fortunes, started dropping.

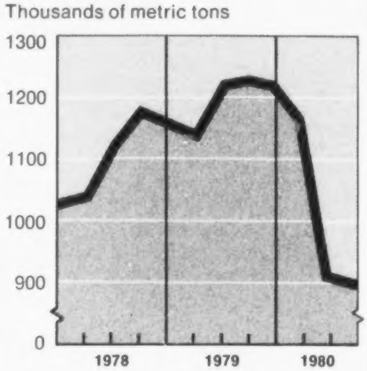
In the second quarter of 1980, ethylene output fell to 1.17 million metric tons, down 4.3% from the first quarter. Complete figures aren't in yet, but ethylene production in the July-September period probably will weigh in at around 915,000 metric tons, another 22% drop.

Unless the government's economic measures help quickly, ethylene producers probably will lower output slightly in the fourth quarter of the year. At best, it won't go up very much.

Production cutbacks are percolating throughout the entire industry. Kashima Vinyl Chloride Monomer Co., the largest producer of vinyl chloride in Japan, shut down one of its two lines recently. It probably still is operating at 50% of capacity. Earlier, other vinyl chloride producers cut production an average 30% and further cutbacks seem inevitable.

Demand for high-density polyethylene in the third quarter has been revised downward from its original 146,000 metric tons to a lower 140,000 metric tons. In the last quarter, observers estimate that demand will be 7 to 8% lower than in the last quarter of 1979. Nippon Petrochemicals has shut down its plant as a result.

Japanese ethylene output is turning down



Note: Third and fourth quarters of 1980 are estimates. **Source:** Ministry of International Trade & Industry

Lower demand and production cutbacks can be found everywhere throughout the plastics and fiber industries. The same is true for the intermediate petrochemicals that feed them. Now, MITI is talking to aromatics producers to see what can be done to improve a deteriorating supply-demand situation.

Not surprisingly, this turn of events has made it difficult for petrochemical companies to raise prices further. In fact, instead of pushing hard for price increases, companies are fighting requests for price cuts.

Ethylene producers are being hounded by derivatives producers to set "special" lower prices for ethylene that is used to produce chemicals for export. That's because, not only has the domestic market turned sluggish, but exports, particularly to Southeast Asia, have been hurt by competition from the U.S.

The consequences of the deteriorating petrochemical situation in Japan are easy to foretell. Profits are going to take another beating.

Based on data compiled by Toyo Kelzai Shinposha, C&EN estimates that the net profit of Japan's 10 largest chemical companies will drop to 34.4 billion yen in the second half of fiscal 1980 ending next March.

Average profit margins will slip to 1.26% of sales from the 2.0% that they were in the second half of 1979.

Nomura Research Institute figures confirm the trend, if not the exact numbers. Based on a survey of 29 Japanese chemical companies, the institute estimates that industry profits will drop 18% in the reporting period that ends this month. And they will go down another 3% in the second half of fiscal 1980.

Japanese petrochemical executives aren't naive enough to believe that last year's production and profit spurt spelled an end to all of their problems. But the few who may have been lulled into a false sense of complacency have been shaken out of it by what's happening to Japan's petrochemical industry now.

The problems still exist. They still must be solved. And the raw material situation stands high on the list.

With ethylene and other chemical production curtailed, Japanese chemical companies find themselves in the unfamiliar position of having excess naphtha. Japanese refiners can't cut naphtha production any further. This means that chemical companies have stopped importing naphtha on a spot basis and are postponing deliveries due under long-term contracts. The irony of all this is that domestic naphtha now is more expensive than imported naphtha.

But chemical producers know that excess naphtha won't always be the order of the day. In past periods of shortage, chemical companies have switched part of their production to liquefied natural gas, butane, and propane.

That's one solution, but it's only a partial solution. Over the long haul, petrochemical feedstock in Japan will be characterized by a trend to heavy liquids.

MITI has organized a petrochemical industry raw materials problem committee to analyze the supply-demand situation both in Japan and overseas. The committee also will examine possible approaches to fuel switching and feedstock diversification.

Meanwhile, the industry will be watching carefully progress of the so-called "C_1 project." Individually, several Japanese chemical companies have been looking into C_1 chemistry. But now, 14 companies are joining with Sagami Chemical Research Center to form a research association. Its goal is to develop the technical know-how necessary to use carbon monoxide as a raw material for chemicals.

Before the association was formed, MITI already had obtained a budget appropriation to promote the C_1 project as a major, national undertaking. Plans call for developing technology to make acetic acid, ethylene glycol, olefins, and alcohol.

Another raw materials option is to build plants in other countries, where raw materials are abundant. Japanese chemical companies are pursuing this option with a vengeance. Major petrochemical complexes are under way or planned in Singapore, Iran, and Saudi Arabia.

Ground-breaking ceremonies for the Singapore project took place in

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July. Officially, it is known as PCS—Petrochemical Corp. of Singapore. An ethylene producer that will be able to turn out 300,000 metric tons a year by late 1982, PCS is owned equally by Singapore and Japan. But it is mainly a Sumitomo project, with leadership provided by Sumitomo Chemical, Sumitomo Corp., and Sumitomo Bank.

Assured naphtha supplies will come from Esso, Shell, and Singapore Petroleum refineries. Meanwhile, PCS will give birth to many downstream ventures, including plants to make low- and high-density polyethylene, polypropylene, ethylene glycol and oxide, and acetylene.

About 70% of the complex's output will be exported to Southeast Asia. This, of course, will affect Japan's own exports of petrochemicals to the region.

Work is just starting to resume on the oldest of the three major overseas projects. This is the Bandar Shaphur complex (since renamed Bandar Khomeini) in Iran. Proposed in 1968 and with construction started in 1971, the complex still is only 85% complete.

For the past year and a half, the project has gone untouched because of the political turmoil in Iran. But the Iranian government has been pushing Japan to resume the project.

Five major Japanese investors—Mitsui & Co., Mitsui Toatsu, Mitsui Petrochemical, Toyo Soda, and Japan Synthetic Rubber have agreed to do just that. The five hold equity shares in Iran Chemical Development Co., the Japanese partner with Iran in the $3.3 billion project.

At the center of the complex will be a 300,000 metric-ton-per-year ethylene plant. Parts of the plant already built have deteriorated and no one is really certain just when the project will start operating.

The third offshore project is in Saudi Arabia. Right now, only a feasibility study is under way, and that won't be completed until next year. Only then will final details for the project be worked out.

If the study shows that the project can fly commercially, construction of the ethylene unit might start later in 1981. The project will be a joint venture between Saudi Arabian Basic Industries Corp. and 54 companies of the Mitsubishi group.

Already, the partners have agreed to increase targeted capacity of the ethylene plant from its original 300,000 metric tons annually to 450,000 metric tons. The complex, which will include the usual cadre of downstream units, will be built at Al Jubail.

All three projects, in Singapore, Iran, and Saudi Arabia, are "national projects," promoted and heavily financed by the Japanese government. The government has its own reasons for promoting them. With Singapore, it was to mend political and economic fences in Southeast Asia. The Iranian and Saudi projects are meant to secure a stable supply of crude oil for Japan.

For its petrochemical industry, however, these projects mean something else. They mean that petrochemical companies will have to alter the way they do business.

Many of the petrochemicals that Japanese companies export to Southeast Asia and to other markets as well will be supplied from these offshore plants. These plants also will be shipping sizable volumes of basic and intermediate chemicals back to Japan.

What this means is that, in Japan, additional capacity and production of basic and intermediate chemicals will grow very slowly in the future. Much of the new capacity that will be added will be to replace antiquated and inefficient units.

It also means that Japanese companies will have to realign their product mix. The emphasis will go toward products that are more sophisticated technically and that have a higher value-added content.

That's the design of many Japanese chemical companies with an eye toward improved profits. The trend already is under way. Teijin, for instance, hopes to expand its engineering plastics business 20% per year. Mitsui Petrochemical Industries and Honshu Chemical recently agreed to launch a joint project to develop more valuable products based on phenol, aniline, and cresol.

Sumitomo's Hasegawa says that Japan's chemical industry has to depend upon proprietary technology based on its own research to survive. "The days have passed," says Hasegawa, "for the chemical industry to achieve its growth by mass production of commodity products."

He is right, of course. But Japan's petrochemical industry has to do even more. The industry is fragmented, with many companies that are smaller than their U.S. or European counterparts. Marketing power is much lower.

It has to restructure itself. But that is easier said than done. In its study of industry's problems, the Japan Chemical Industry Association points out that the number of Japanese petrochemical companies would have to be cut in half if the industry hopes to have enough muscle to compete with other industrialized nations. □

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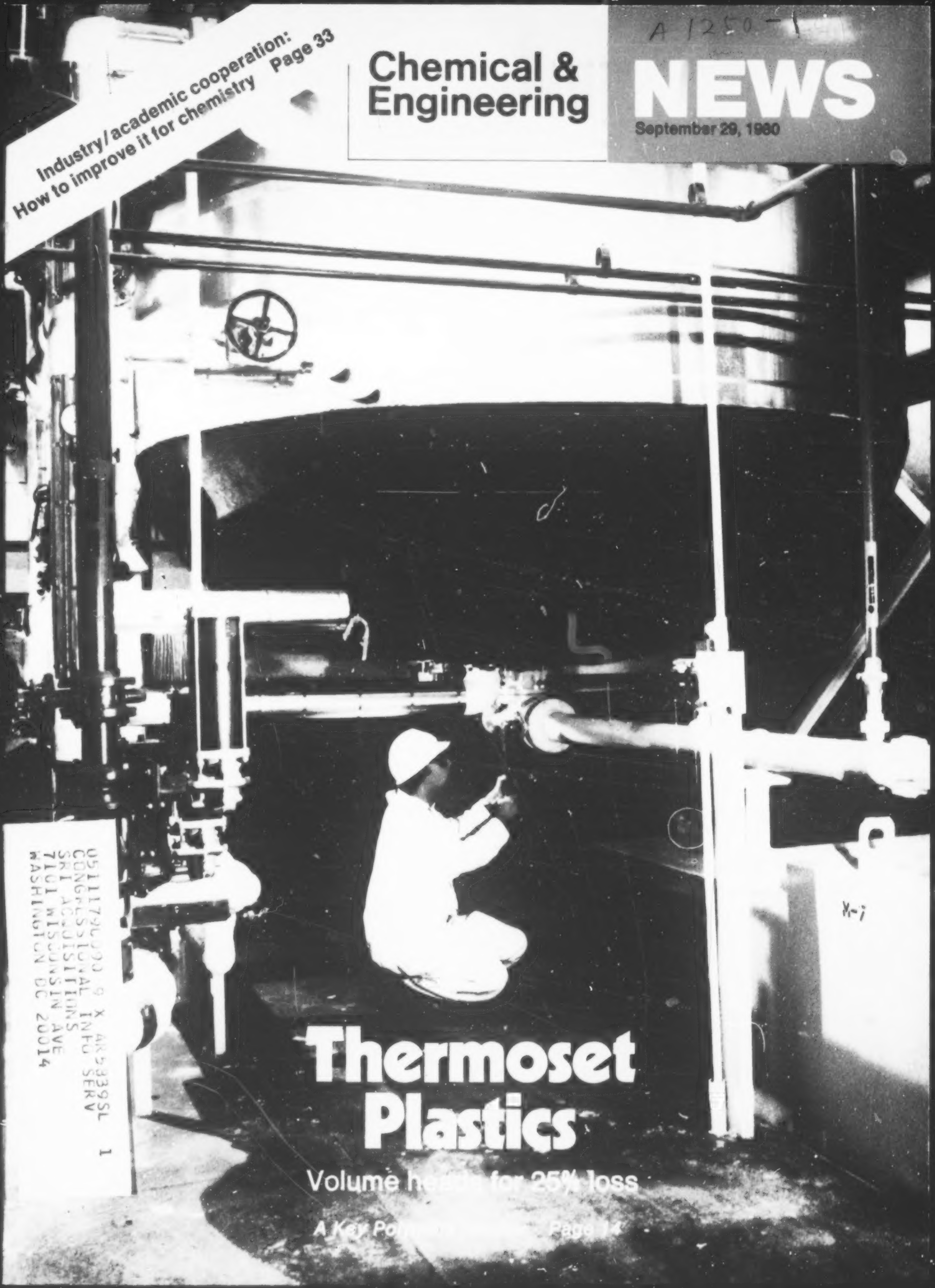

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Thermoset plastics hit hard by recession

Drop in consumer demand for durable goods—thermosets' major markets—is leading to 25% loss in volume; recovery isn't likely until 1982

To economists, the U.S. recession expected in 1979 was delayed to 1980. For producers of thermoset resins, it was dismayingly punctual.

Rises in 1979 inflation and interest rates translated into higher prices for new houses, cars, appliances, and other durable goods—the dominant thermoset markets—as well as higher costs of loans to buy them. Thus for consumer durable goods, and hence for thermoset resins, the decline began in 1979, followed by other segments of the economy in the first quarter of 1980.

The same chilling effects of inflation and interest rates persist in 1980, meaning that thermoset markets will not make quick recoveries. Thus many thermoset producers do not see their sales regaining heights reached in 1978 until 1982 or 1983. In other words, 1981 could be a hard pull.

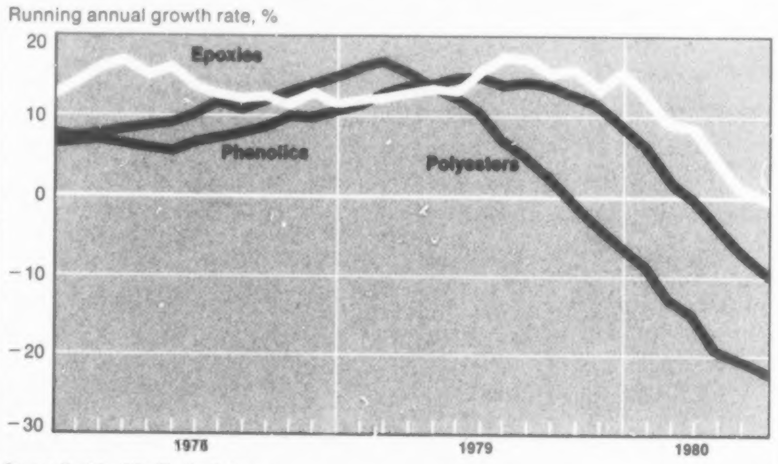
Among the major thermosets, unsaturated polyester started down first. Production posted a 5% drop from 1.21 billion lb in 1978 to 1.12 billion lb in 1979. The decline began abruptly in April 1979 when lines at gasoline stations formed, reviving memories of the gasoline panic of 1973 and driving down sales of boats and recreational vehicles. The slide continued unabated to the present with successive falloffs in housing starts and domestic sales of U.S.-made autos.

Phenolics followed by midsummer 1979, undercut by falling construction and auto markets, and wound up registering a 6% loss from 1.68 billion lb in 1978 to 1.58 billion lb in 1979, on a 100% resin basis. These figures are somewhat lower than those reported by the U.S. International Trade Commission because C&EN subtracts an estimate for molding compound fillers.

Only epoxy resins held up to the end of 1979. Sales advanced 5% from 1978 to 332 million lb. This upbeat performance in the face of adversity elsewhere results from use of much of epoxy volume for high-performance industrial coatings and for electronic devices. A healthy export market, amounting to 10% of production, also helped offset epoxies' losses.

High inflation rates helped to sap the consumer durables markets on which thermoset sales depend. As measured by the consumer price index, inflation was less than 8% in 1978 but rose to 11% in 1979, with a brief spike to 18% in the second quarter. The inflation rate may continue at about 10% in 1980 and 1981, contributing to further erosion in consumer spending and delaying recovery for one or two years.

Growth slacks off for major thermosets



Source: Society of the Plastics Industry

High interest rates are another deterrent to consumer buying in the industries where thermoset resins makers sell their products. Such interest rates also chill investment by thermoset customers in production facilities for consumer and industrial goods. The prime rate was 9% in 1978, which itself is not low, and drifted upward in 1979. By the end of 1979, the prime rate was 15% and still rising. The rate shot up to 20% in April 1980, then declined to 11% by midsummer. But interest rose past 12% in September. If persistent inflation leads the Federal Reserve Board to tighten the money supply, the prime could be at 15% at the beginning of 1981, just when thermoset manufacturers hope to turn their falling fortunes around.

Sales of U.S.-produced autos sank 8% in 1979 to 8.4 million units. Some economists estimate the figure could drop another 15% in 1980 to 7.2 million cars. While imported auto sales also will decline somewhat for all of 1980, they may comprise 25% of the U.S. market. These sales of imported cars represent resin markets garnered by foreign producers.

Housing starts dropped 14% in 1979 to 1.7 million units. There may be a further fall of 35% in 1980 to 1.1 million. Persistently high interest rates in 1980 could chill chances for a spring 1981 recovery of this important thermoset market.

These circumstances in interest rates and inflation don't really surprise thermoset producers, who weathered much the same thing before in the 1974–75 recession and to a lesser degree in earlier recessions. The prescription now may also be somewhat like the recovery course from previous recessions—wait it out.

For example, thermosets had to idle through the first recovery year of 1976 after the 1974–75 recession before their markets took off again. The same thing happened in 1971 after the 1970 recession.

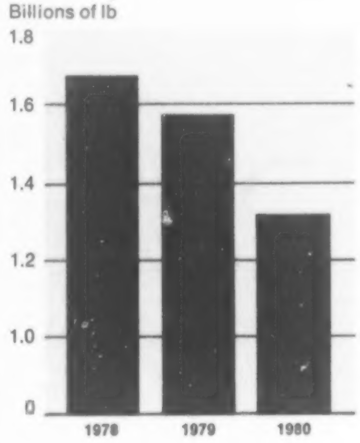
Stephen Stinson, New York

Key Polymers

Phenolics

- ***Prices dropping***
- ***Capacity plentiful***
- ***Markets falling***

PRODUCTION



HOW MADE

Condensation of formaldehyde and phenol. One-stage products cured by heating; two-stage products cured by heating with hexamethylenetetramine

MAJOR END USES

Plywood 34%, glass fiber insulation 19%, molding compound 8%, foundry resin 8%, fibrous and granular wood 8%

FOREIGN TRADE

Exports—2% of total production, imports—negligible

PRICES

38 cents per lb, 100% solids basis

COMMERCIAL VALUE

$500 million for total production, 1980

U.S. phenolic resin sales started losing momentum in midsummer of 1979. By the end of the year, the U.S. International Trade Commission had recorded an 8% drop to almost 1.8 billion lb from the all-time high of more than 1.9 billion lb produced in 1978.

The slide continues in 1980, with industry predictions of a further 15 to 20% fall to 1.4 billion to 1.5 billion lb. If continuing inflation and new rises in interest rates prevent early recoveries in important automobile and construction markets, the result could be a 25% decrease to 1.3 billion lb this year.

Recovery likely won't be easy. The phenolic resin industry probably will hit bottom in the first quarter of 1981. But a weak rise in construction in the spring, followed by a delay in auto recovery until 1982 model cars, could limit phenolics sales to 1.4 billion to 1.5 billion lb in 1981. Eventual recovery to 1979 peak levels could come as late as 1983.

With 85% of phenolic resins going to industrial adhesive and bonding applications, these products are highly susceptible to downturns in construction, car sales, and general manufacturing. For example, about 600 million lb of phenolic resins was used to make plywood in 1979, almost 300 million lb as a binder for glass fiber insulation, 110 million lb for laminates, and 140 million lb for fibrous and granulated wood.

In automotive and general manufacturing, about 130 million lb of phenolic resins was used in 1979 as foundry core binder for metal castings. Phenolic molding compound for plastic parts consumed almost 130 million lb of resin to make 310 million lb of compound.

Molding compound sales rose about 3% in 1979 over 1978. This small rise was a weak recovery after an 8% loss in 1978 compared with 1977. The overall trend in molding compounds has continued downward at an average rate of 3% annually since 1976.

Countering this drop, such advances as runnerless molding have made phenolics somewhat more attractive by cutting scrap rates. And continued price increases in thermoplastic molding resins may net more attention for phenolics. Molding compound producers are pinning their hopes on adoption of phenolics by automobile manufacturers in 1981 and beyond as a part of Detroit's efforts to improve gasoline mileage by reducing car weights. Nevertheless, thermoset molding times are longer than those of thermoplastics.

Continued increases in oil and natural gas prices are likely to spur continued growth in phenolic resins for energy-saving glass-fiber insulation. This application grew at annual rates of 15% in the mid-1970's, a rate that may resume with an upturn in construction. Phenolic foam boardstock also has gained interest as insulation because of its thermal insulating efficiency, low flame spread, and smoke generation ratings in comparison with other materials. These products have had minimal sales in the U.S. to date, however.

Phenolic resin producers tried to increase prices over the 1979 average 38 cents per lb on a 100% resin basis during the first quarter of this year. But continuing deterioration of phenolics markets led to a rollback to 1979 levels. Renewed rising prices of oil-derived benzene and especially natural-gas-based methanol and formaldehyde may provoke a rise in phenolics prices to 44 cents in the 1981 recovery year.

Each 100 lb of phenolic resin takes about 70 lb of benzene in the form of phenol and 40 lb of formaldehyde made from methanol. In addition, laminating varnishes consume 9 million to 11 million gal of methanol diluent yearly. Though under pressure in 1980, list phenol prices are still 50% higher than at the beginning of 1979 and have doubled since 1977. Methanol and formaldehyde list prices also rose 50% in 1979 and 1980 after being quiescent since 1977. Further price rises in methanol and formaldehyde may come in 1981 after this year's holdup.

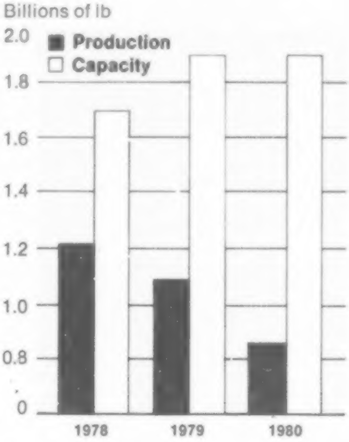
Production and sales of phenolic resins are hard to gauge because of difficulties in collecting data. Until 1980, some large producers' figures were not accurately represented in monthly figures compiled by Ernst & Whinney for the Society of the Plastics Industry. Both SPI and ITC report on a 100% resin basis, except for molding compounds, which may be 60% fillers. C&EN has used ITC data, after subtracting an estimate for molding compound filler weights, to arrive at production levels of 1.68 billion lb in 1978, 1.58 billion in 1979, and 1.32 billion in 1980.

Key Polymers

Polyesters

- ***Prices discounted***
- ***Capacity ample***
- ***Markets plunging***

PRODUCTION/CAPACITY



HOW MADE

Primarily polyesterification of maleic and phthalic anhydrides with propylene glycol; cross-linked with styrene

MAJOR END USES

Construction 29%, marine 20%, castings 14%, transportation 9%

FOREIGN TRADE

Exports—1% of total sales, imports—negligible

PRICES

General-purpose grade, 54 cents per lb

COMMERCIAL VALUE

$460 million for total production, 1980

Unsaturated polyester markets started falling apart in April of last year. The rout began when gasoline lines and an ensuing 25% jump in gasoline prices scuttled marine and recreational vehicle sales. Loss of boat sales has a special impact on polyesters because 65% of the reinforced plastic used in boats is resin, compared with 18% for some other reinforced laminates. Further erosion for polyester occurred with market downturns in construction, automobiles, and appliances.

Last year ended with a 4% drop in polyester sales to 1.15 billion lb, according to figures compiled by Ernst & Whinney for the Society of the Plastics Industry. Sales may fall another 25% to 860 million lb in 1980, though some especially bearish observers see sales plummeting to 720 million lb.

An upturn in most unsaturated polyester markets is expected in the first quarter of 1981, though recoveries in boats and recreational vehicles may be delayed far longer. Sales may reach 1 billion lb in 1981, spearheaded by new applications in auto-body parts, followed by recovery to 1978 levels in 1982. More conservative forecasts are 940 million lb in 1981 with full recovery delayed until 1983.

Some bright spots persisted in polyester markets in 1979. Continued industrial plant construction resulted in a 14% rise to 97 million lb for polyester use in corrosion-resistant tanks and pipes. In addition, use in consumer goods such as recreational products, seating, and serving trays rose 9% to 160 million lb.

In another market—general construction, tank, pipe, and bathroom fixtures—polyester use fell 10% in 1979 to 228 million lb. However, polyester use in imitation marble for vanities rose 15% to 67 million lb, possibly reflecting persistent health in home remodeling and improved marketing efforts by that industry segment.

Overall sales losses for polyester still outpaced these rises in small markets. In the worst area, the marine market fell 9% to 227 million lb in 1979 and lost another 40% in the first half of 1980 from the first half of 1979. Auto, truck, bus, and other transportation applications dropped 12% to 105 million lb last year, and have thudded with another 40% drop so far in 1980. The overall corrosion-resistant market, which flowered late in 1979, is now off 7% year-to-year in 1980.

These troubled times also have dispelled some old myths about recessions. One myth is that when people can't buy new cars, they repair their old ones. But sales of polyester for auto-body putty decreased 9% in 1979 to 45 million lb and 27% so far in 1980.

Another myth is that people remodel their present homes when they cannot build new ones. But polyester use in imitation marble for vanities probably will drop 14% in 1980.

Although only 1.5% of total polyester production is exported by primary resin makers, according to SPI, the U.S. Bureau of the Census reports that almost 10% of U.S. polyester resin eventually winds up abroad through distributors. Of this 111 million lb, almost half went to China in 1979, Census says.

Average U.S. polyester resin prices have fallen from 54 cents per lb in 1979 to as low as 51 cents now. As markets recover in 1981, prices probably will rise toward 60 cents per lb, propelled by increasing raw materials costs. For example, raw material phthalic anhydride is made mostly from *o*-xylene, and raw material maleic anhydride mostly from benzene. The cost of these petrochemicals depends on oil prices.

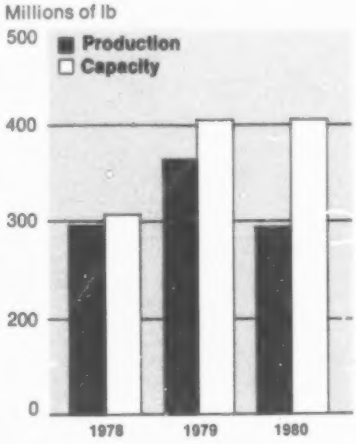
More impetus for rising polyester prices will come from U.S. deregulation of natural gas prices. This will affect polyester raw materials such as propylene glycol. In addition, the U.S. source for maleic anhydride is expected to shift from benzene to natural-gas-derived butane in coming years, dictated partly by Environmental Protection Agency limitations on benzene emissions from maleic anhydride plants.

Other regulatory concerns may add to economic ones for polyester in the coming year. For example, the National Institute for Occupational Safety & Health is expected to recommend to the Occupational Safety & Health Administration that the present 100-ppm, eight-hour worker exposure limit to styrene vapor in plant air be decreased to as low as 25 ppm. The industry will counter with data from a study suggesting that no health advantage will accrue from the change.

Epoxies

- ***Prices steady***
- ***Capacity adequate***
- ***Markets slipping***

PRODUCTION/CAPACITY



HOW MADE

Reaction of bisphenol A with epichlorohydrin followed by cross-linking with hardeners

MAJOR END USES

Coatings 44%, laminates and composites 18%, molding 9%, flooring 6%, adhesives 5%

FOREIGN TRADE

Exports—11% of sales, imports—negligible

PRICES

Average $1.00 per lb

COMMERCIAL VALUE

$295 million for total production, 1980

Epoxies did not begin to feel the chill of the current U.S. economic downturn until the end of 1979, when sales growth was still at a 5% annual rate. This relative resistance to economic weakness, characteristic of epoxies, results from reliance on high-performance, high-technology uses compared with those of other thermosets. Such uses include semiconductor devices, adhesives and parts for airframes, industrial and beverage can coatings, and tanks and pipes for the oil and chemical industries.

But even epoxies fell victim to the overall slowing of the economy in 1980. The running annual growth rate fell to zero by August. By the end of the year, production and sales may be 18% lower than in 1979. With recovery impeded by continuing high inflation and interest rates, epoxy resin production may not return to 1979 levels until 1982.

According to figures compiled by Ernst & Whinney for the Society of the Plastics Industry, epoxy resin sales increased 5% in 1979 to a record 332 million lb. Growth resulted from a 13% rise in flooring use to 20 million lb, an 11% increase in laminates and composites to 54 million lb, and a 3% lift in coatings to 146 million lb. These gains offset small declines in adhesives to 17 million lb and in casting resins to 31 million lb. Though almost all markets now have turned down, laminates and composites continue strong growth, buoyed by the electronics industry.

Epoxies also have a vigorous export market compared with other thermoset resins. According to SPI, 10% of total production was exported in 1979 by base resin makers, and this strength has continued this year. The Bureau of the Census, which counts eventual resin exports by all firms including distributors, reports exports of 22% of all production. Part of this strong export picture results from lower prices of raw materials in the U.S., as well as high efficiencies of a few large U.S. plants.

Most of this burgeoning foreign market results from export of U.S. electronics and coatings technology. Users of these technologies in other countries often specify the same resin that was used successfully here. In addition, epoxy markets in many countries are too small to support domestic epoxy production. Thus exports from the U.S. will continue from large, efficient plants until local foreign consumption justifies domestic plants there.

Beyond the current recession, prospects for epoxies seem especially bright. Manufacturing customers use these high-priced, high-performance resins because they have to, not because they want to, in order to get better product properties. Epoxies cost two to three times as much as phenolics or unsaturated polyesters for adhesives, coatings, and molded parts. Thus, among major thermosets, epoxies are most likely to open up whole new high-specification major market categories while defending themselves against losses to competing materials.

Government regulation may give birth to some of these important new uses. For example, pressure to change from solvent-based to high-solids, water-based, or powder coatings in many industries could lead to penetration of these industries by epoxies at the expense of other resins. Whether it is ever made law, the current trend of auto makers toward offering warranties against corrosion is likely to increase use of epoxy coatings on cars.

Like other thermoset producers, epoxy makers have high hopes that Detroit will choose their products for heat- and stress-resistant parts to reduce automobile weight in the early 1980's. Epoxies certainly have the properties for these end uses, but whether their cost-performance ratios will excel those of phenolics or polyesters is still an open question.

The toxicity picture for epoxy resins also seems brighter this year. Although concern has arisen over possible carcinogenicity of residual epichlorohydrin in base resins, cooperative industry studies soon may be released that indicate negligibly low levels in the air of well-ventilated fabricating plants that use good work practices. These levels are well below the 5-ppm eight-hour standard set by the Occupational Health & Safety Administration.

Suspicions of carcinogenicity also may have been lifted from butyl glycidyl ether, a diluent used in many epoxy formulations. A 1979 report at the University of Texas of older studies suggests that the diluent is not mutagenic in animal skin painting tests.

Canadian chemicals growth slows sharply

The rapid pace of growth maintained by the Canadian chemical industry for the past three years now has slowed to a crawl, for the most part.

Although most of Canada's largest publicly reporting chemical companies could boast of increased sales and earnings in the first half of 1980 (C&EN, Aug. 11, page 16), those boasts were couched in terms of dollars. In terms of real output, the trend has been one of stagnation, according to figures from Statistics Canada.

The chemical production index showed small monthly increases from July 1979 through March 1980. But April brought a sharp drop in the index, followed by a slight rebound in May and another drop in June. At the end of June, the index was only minimally higher than it was a year earlier. At least it was an increase; the all-industry index declined about 4% during the same period.

Trends notwithstanding, production of some chemicals, including fertilizers (making a strong comeback after a lackluster 1979), caustic soda, chlorine, major acids, and ethylene, increased substantially during the first half of 1980. But production of benzene was down slightly during the period. Production of butadiene and carbon black was off significantly, reflecting the tire industry's current hard times. And after four years of whopping gains, all the major plastics also posted production declines.

Chemical prices rose slowly during the second half of 1979, then jumped sharply at the beginning of 1980. Producers' quarterly adjustments brought another, smaller leap in April. In June, the chemical price index actually dropped just a bit, although it inched upward again in July, according to preliminary figures. At the end of July, the index was about 17% higher than it was a year earlier; it appears unlikely, however, that that rate of increase will persist in the next several months. The chemical price index continues to run slightly ahead of the all-industry index.

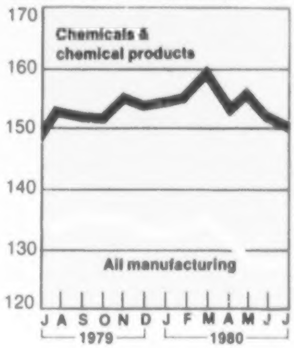
Canada's chemical exports continue to run strong; in fact, much of the good news in second-quarter sales and earnings reports was attributed to booming export sales. Exports were particularly strong for fertilizers, organic chemicals, and synthetic rubbers and plastics. At the same time, the trend of chemical imports has been downward, and Canada's chemical trade balance is, at least for the present, solidly in the black.

The spring slowdown put a dent in the Canadians' resolve to keep inventories under control. Chemical shipments, even in terms of inflated dollars, actually declined in May and June. At the same time, inventories rose steadily. The inventory-to-shipments ratio, after having fluctuated within tolerable limits (less than 2.00) for most of the period, suddenly jumped to an unnerving 2.43 in May and rose again to 2.57 in June. Preliminary figures for July show only a marginal change in the ratio (to 2.46), but at least the change is in the right direction. The all-industry ratio also has risen, but not so sharply.

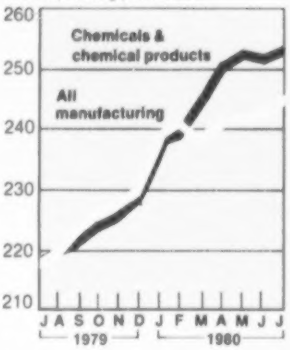
Despite some signs that the recession may have "bottomed out," most Canadian economists are gloomy about the near-term outlook. In general, they predict that 1980 will be a "no-growth" year for Canada, and that there will be only slight recovery in 1981.

Ward Worthy, Chicago

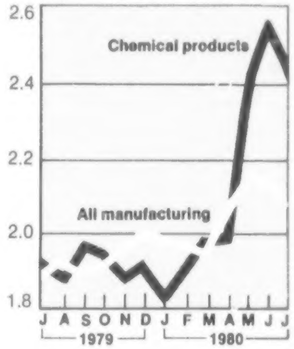
Volume index, real domestic product[a]



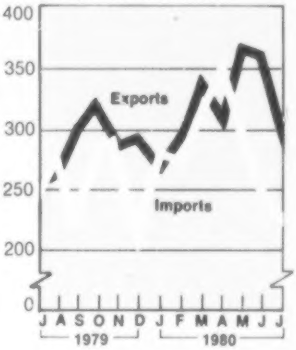
Industry selling price index[b]



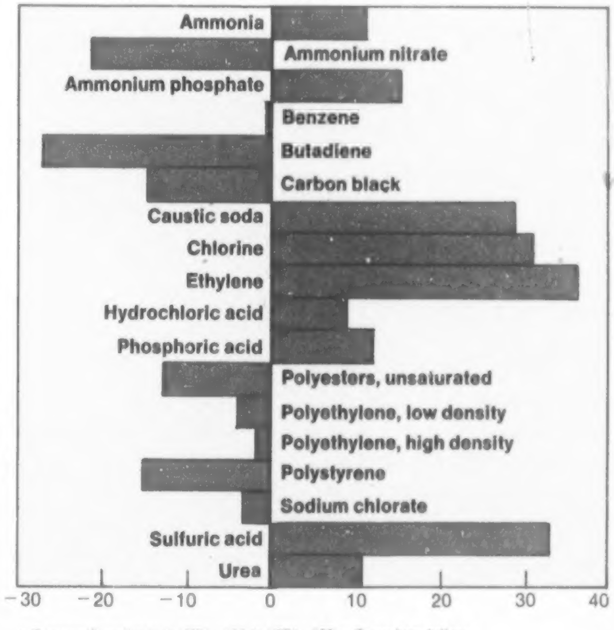
Ratio, inventory to shipments



Chemical products, $ millions[c]

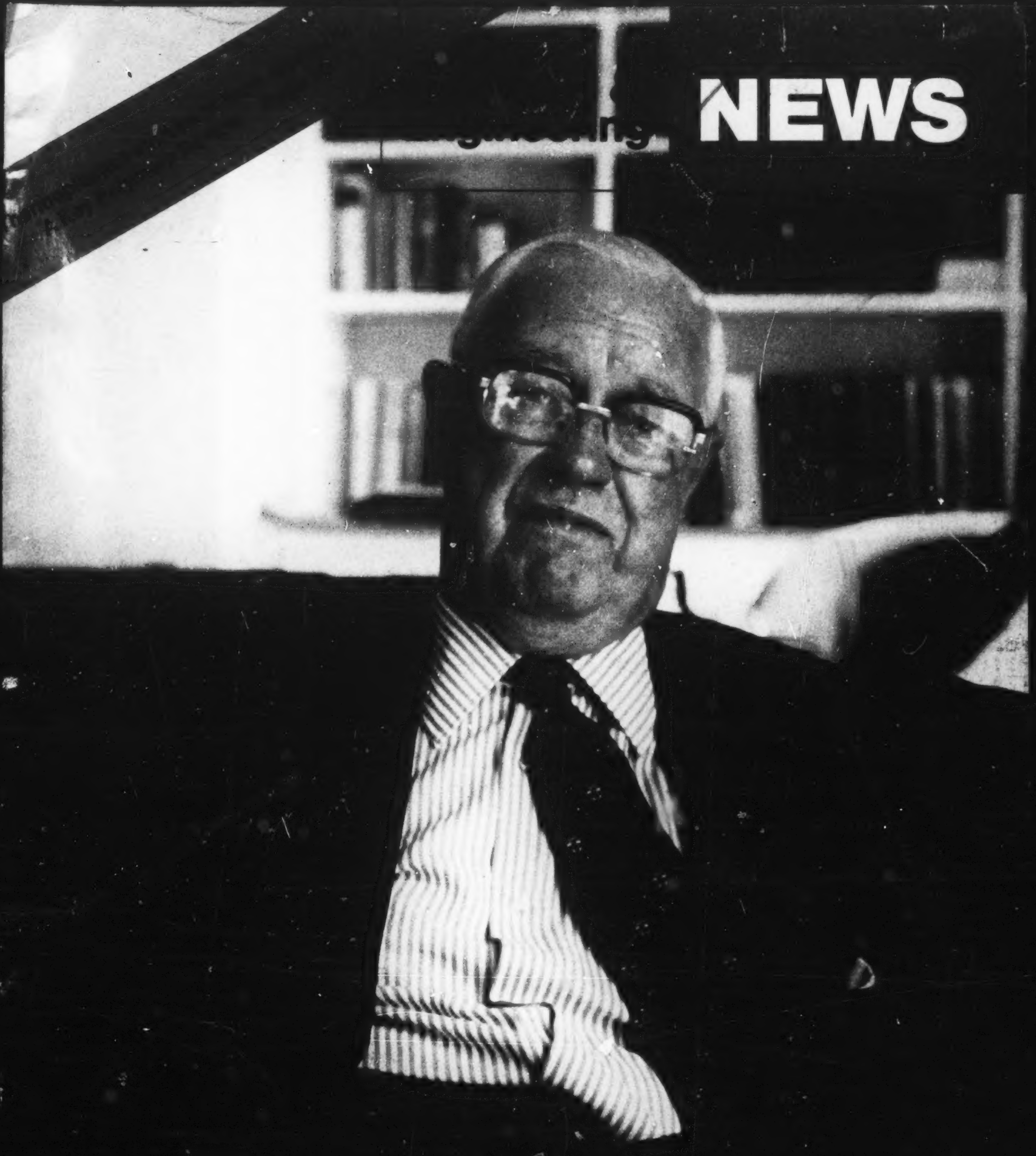


First-half production, % change from 1979



a Seasonally adjusted; 1971 = 100. b 1971 = 100. c Canadian dollars.
Source: Statistics Canada

Engineering NEWS



The state of chemistry

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of the Royal Society — Page 98

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News of the Week

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- ***Petromont,** joint venture of Canadian firms and Quebec government, takes over ethylene operations in Montreal area.* ***Page 7***
- ***Experimental vaccine against hepatitis B,** developed by Merck, proves 92% effective in large-scale clinical tests.* ***Page 7***
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Business

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WASTE SITES POSE RISK TO WATER SUPPLY

A House subcommittee has released a list of more than 2100 industrial waste sites where hazardous chemicals may be leaching into groundwater supplies, and singles out 250 sites where hazard to usable public drinking water supplies may be imminent. A report containing the list was prepared by the Subcommittee on Environment, Energy & Natural Resources using data collected over the past two years by the Environmental Protection Agency.

Subcommittee chairman Toby Moffett (D.-Conn.) says the investigation has led the subcommittee to call for formation of a national groundwater policy as soon as possible. "Based on the [limited] criteria used and the data asked for, it is striking just how many hazardous sites there are," Moffett says.

The report stresses that it is not accusing the owners or operators of the specific sites of polluting groundwater. The significance of the list, it states, is in the considerable number of these sites and how many of them may have impoundments that pose a contamination risk to water supplies.

The EPA data show the locations and owners of more than 170,000 so-called surface waste impoundments. These include agricultural runoffs, septic tank cleaning, pits, ponds, lagoons, and other waste-holding areas. It does not include places such as farm ponds, storage tanks, irrigation ditches, or domestic sewage treatment systems.

EPA survey shows most waste areas are not industrial sites

Category	Located sites	Assessed sites	Located impoundments
Industrial	10,819	8,163	25,749
Municipal	19,102	10,792	36,161
Agricultural	14,373	6,562	18,765
Mining			
Noncoal	1,688	616	4,026
Coal	5,388	837	20,350
Oil and gas brine pits	24,527	3,314	64,951
Other	1,761	680	6,645
TOTAL	77,678	30,964	176,647

Source: EPA report "Surface Impoundment Assessment," June 1980

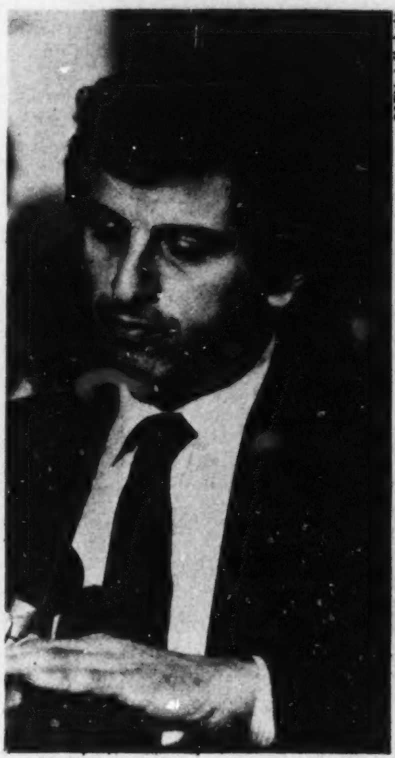
Of the total, fewer than 26,000 are listed as industrial waste storage impoundments. As much as 70% of these are thought to be unlined; that is, there is no barrier to prevent leaching of wastes into groundwater. About 30% of the total, or 7800 impoundments, are listed as having no barriers and are "directly on top of" groundwater sources. In a final breakdown, there are 250 sites believed to contain hazardous chemical wastes and that are unlined and are within 1 mile of a public water supply well.

These hazardous sites are located in 35 states, according to the following distribution: Florida 54; South Carolina 23; Ohio 21; Pennsylvania 20; Connecticut 18; Mississippi 14; Missouri 13; Michigan 11; Tennessee 10; Arizona nine; Indiana eight; New York and New Jersey, six each; California and Massachusetts, four each; Louisiana three; Colorado, Kansas, Iowa, Maryland, North Carolina, Wisconsin, and West Virginia, two each; and Minnesota, New Mexico, Vermont, Washington, Delaware, Illinois, Kentucky, Montana, Oregon, Texas, Virginia, and Wyoming, one each.

Moffett is careful to emphasize the uncertainty and preliminary nature of this information. "Because these data are from the states, we cannot vouch for their accuracy," Moffett says. "Some of the sites may be safe, but all appear to be candidates for serious problems." The report states that most of the data was not collected from owners or operators of the sites and that information sources were often second-hand. Many of the sites apparently were not examined by state officials directly. In all, the report says the data provide "a first round approximation of the magnitude of the problem."

Because of the uncertainty of the data, the subcommittee is preparing a questionnaire to be sent to the owners or operators of the sites listed in the EPA study. It is expected to be sent out soon, and the subcommittee likely will have some results by this winter.

The report is only the first of a series of investigations by Moffett's subcommittee into groundwater pollution and is part of Congress' growing concern about the problem. Moffett already has held hearings on the issue and says he may call for more hearings in November. In addition, joint hearings on the same issue were held in August by the House subcommittees on Transportation & Commerce and on Health & the Environment.



C&EN staff photo

Moffett: possible serious problems

Several recommendations are presented to EPA in the report. It asks the agency to continue to cooperate with the states in formulating as quickly as possible a definitive national groundwater policy.

The report urges EPA to use its existing statutory authorities to their limit to protect groundwater sources. These authorities come primarily from the Resource Conservation & Recovery Act, which currently is being revised.

In addition, the subcommittee gives EPA a mandate to report to Congress within 120 days on the progress it has made, if any, toward these goals. The agency also is asked to detail whatever additional resources and authorizations are needed to protect the nation's groundwater supplies. ◻

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Thermoplastics begin uncertain recovery

Both production and sales have moved up from low point for polyethylene, polyvinyl chloride, polypropylene, and polystyrene

Bruce F. Greek, C&EN Houston, and William F. Fallwell, C&EN New York

Has the recession safely ended for the major U.S. thermoplastics? As the third quarter drew to a close, industry opinion generally was yes, the production low point has passed for low- and high-density polyethylene, polyvinyl chloride, polypropylene, and polystyrene. Sales of these polymers, detailed on the following pages, also are up steadily from the troughs of early summer.

Now the big question is whether the resurgence will last. Many marketing executives concerned with the thermoplastics are uncertain. Signs are increasing that a recovery from the recession could stall. Most important, rapid interest rate increases of late could dampen auto sales and housing construction again and throttle back the whole plastics business in the first half of 1981. Real recovery might wait until late in the year.

Thermoplastics managers have to keep an eye on such general performance in the economy because of the very size of the thermoplastics part of the chemical industry. Although still growing considerably faster than constant-dollar gross national product, thermoplastics in their relative maturity are a vital part of most consumer products. Thus, as the consumer and the general economy go, so in a magnified way go thermoplastics.

This has been an unfortunate correlation this year. In 1980, performance of the five largest volume thermoplastics will be substantially lower than in 1979 and also lower than GNP. Estimates now indicate that production of these five thermoplastics will total just over 23 billion lb, down 13% from 1979.

Because of the slump in production, value of these polymers in 1980 will just about equal the value of the greater quantity produced in 1979 at just over $9 billion.

Hence, thermoplastics prices still went up in 1980—a combined average of 15% over 1979 to 39 cents per lb. This means that producers passed on some of their cost increases to buyers.

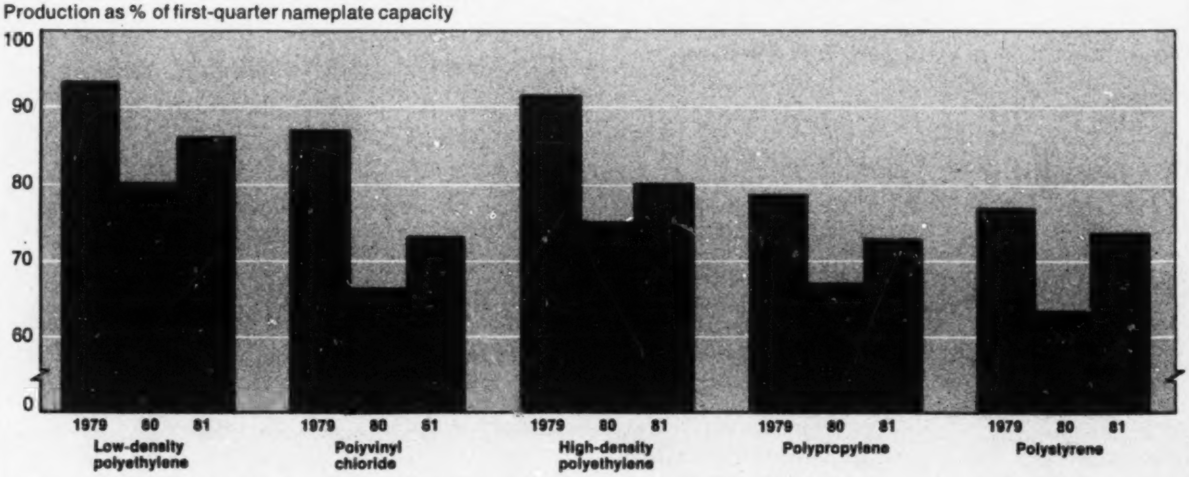
What is not clear is how much of the cost increases producers have had to absorb themselves. Probably a lot, contributing to a big drop in profitability.

The end result from lower sales volume and higher costs is much lower profitability for thermoplastics. Some, especially PVC and polypropylene, staggered under long periods of unprofitable operation during 1980, possibly long enough to wipe out profits for the whole year.

The question now is whether the pickup in thermoplastics sales currently under way will be enough to turn around the profit picture in 1981. Certainly volume will be up unless a severe recessionary tail hits in 1981 because of a renewed credit squeeze. Production of the five major thermoplastics will just about return to the level of 1979 production, reaching 26.5 billion lb if the recovery continues at a moderate pace. Some polymers will do better than others in 1981, with production of high-density polyethylene and polypropylene possibly exceeding that of 1979, although not by much.

Higher production will help spread capital and operating costs thinner and help profitability. However, selling price needs to increase proportionately greater than monomer costs to increase profitability. Most

Even with a marked recovery, plant use in 1981 won't match use in 1979



Sources: Industry and C&EN estimates; Ernst & Whinney for the Society of the Plastics Industry's committee on resin statistics

Production cut in recession is deep, more than sales drop

Although U.S. thermoplastics producers say that they were caught initially with excess production when the economy plunged in late April 1980, they quickly adjusted. Inventories may have ballooned temporarily, but producers worked hard to get them down by slashing production more than the overall sales drop. Monthly figures from the Society of the Plastics Industry's committee on resin statistics as compiled by Ernst & Whinney show an overall 32% production drop for the five leading thermoplastics from January through July 1980, the span currently considered to be the duration of the recession. The sales falloff during this period was 24%. By comparison, in the previous recession, which affected plastics from September 1974 through March 1975, combined production slumped an even worse 40%. However, this rate wasn't much more than the sales drop at the time, which fell a horrendous 37%.

% drop during recession		LDPE	PVC	HDPE	PP	PS	Total
Jan. 1980–July 80	Production	−29%	−38%	−26%	−33%	−35%	−32%
	Sales	−28	−24	−24	−19	−21	−24
Sept. 1974–March 75	Production	−40	−43	−28	−40	−45	−40
	Sales	−35	−39	−28	−41	−40	−37

industry opinion holds that price increases won't be much more than hydrocarbon cost increases, 10 to 20%, unless the current war between Iran and Iraq takes more than 4 million bbl a day from the noncommunist world oil supply. That big a drop in oil supply could dry up the current oil surplus and give chemical companies higher hydrocarbon costs to worry about.

This kind of a thermoplastics price increase would leave nothing basically for improved profit. But it would spark greater efforts to improve plant efficiency. Some technical efficiency gains can result from new plants coming on stream, but high capital costs tend to offset these efficiencies. In older plants, companies are deep in retrofit projects to pick up production economics, especially through energy savings.

Another way to improve resin profitability is to develop specialty grades selling at a premium. Producers are hard at work to lessen their dependence on general-purpose grades.

But overall, 1981 doesn't look like another 1979 for thermoplastics volume or profits. For one thing, 5% more plant capacity has come or will be coming on stream in 1980. With the new capacity, a return to 1979 production levels still would mean average plant operating rates below those of 1979. By present estimates, the combined operating rate for the five thermoplastics will be about 78% in 1981, up from 71% for 1980, but well below the highly profitable 86% in 1979.

Producers are looking to domestic U.S. markets to take most of the 1981 production increase. Exports are up just 9% in 1980 after a 34% jump in 1979. They will do well to equal 1980 in 1981. Their share of total thermoplastics output will drop to 11% in 1981 from 13% this year. In 1979, exports took 10% of production.

The expected exports plateau comes from increasing hydrocarbon costs in the U.S. and a growing recession in Europe, which will influence European thermoplastics producers to sell their products abroad for less. If the Iran-Iraq war causes an increase in oil prices, however, U.S. producers would keep their cost advantage a bit longer.

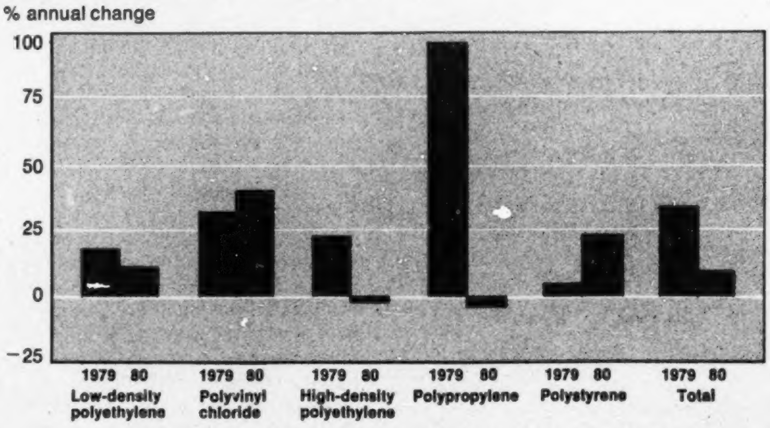
The export and other major factors affecting business in the five major thermoplastics are unnerving reminders of the previous recession of 1974–75: the slump in production and sales as capacity increases, a profitability collapse as prices tumble, and the use of exports to move production as foreign plants face relatively higher costs than plants in the U.S. To many in the industry, the similarities are almost uncanny.

Overall, early data from the Society of the Plastics Industry's committee on resin statistics, as compiled by Ernst & Whinney, suggest that the severity and duration of the decline in these thermoplastics' production have been less so far this time than last—32% from January through July 1980 compared to 40% from September 1974 through March 1975. The sales decline this time, 27%, also is less than the 37% drop last time.

Sales and production declines have hit all the major thermoplastics but have had varying effects on profits. Relative list price changes from a year ago tell much of the story. Obviously, the worst damage is in PVC, whose current price at 31 cents is below 35 cents a year ago. Polypropylene has eked out a mere 1-cent net gain to 36 cents over the past year and has suffered a severe profitability drop. Polystyrene also is barely up in price, 2 cents to 43 cents. The two polyethylenes have fared best, with a 6-cent gain in low-density to 41 cents and a 9-cent increase in high-density to 45 cents, the highest current price among the five major resins. Of course, discounting has reduced much of these apparent price gains.

In handing thermoplastics producers this profit pasting, the recession has seemed to make decisions unnecessary for at least a year, if not two years, on allocating investment money. However, by the end of 1981, indications will be clear, but maybe too late for competitive advantage, on whether plants should be built to be fully in operation two to four years later. Hence, now is the time to make studies and plant commitments, although the latter are in short supply to date. □

Robust thermoplastics export growth in 1979 has subsided overall in 1980



Sources: Industry and C&EN estimates; Ernst & Whinney for the Society of the Plastics Industry's committee on resin statistics

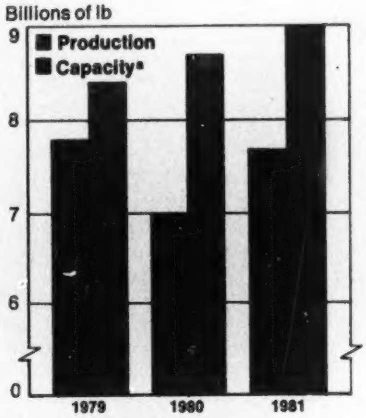
Key Polymers

$-\!\!\left[CH_2-CH_2\right]\!\!-_n$

Low-density polyethylene

- ***Demand reviving***
- ***Capacity rising***
- ***Prices firming a bit***

PRODUCTION/CAPACITY



a Nameplate, first quarter.

HOW MADE

Polymerization of ethylene at high and low pressures aided by initiators

MAJOR FABRICATED FORMS

Film, largely for packaging, 65%; injection molding 10%; coatings 10%; extrusions 5%

FOREIGN TRADE

Exports—rising to nearly 1 billion lb in 1980, imports—negligible

PRICES

Contracts 41 cents per lb for most common grades, discounting prevalent

COMMERCIAL VALUE

$2.8 billion for total production, 1980

Low-density polyethylene's production decline this year may not equal production declines of other thermoplastics in either pounds or percentage points. But this small plus does little to relieve producers of this polymer, largest of the thermoplastics. Even a "wait until next year" attitude holds little solace at the moment, although the situation has begun to improve.

Production of low-density polyethylene in 1980 may do well to reach 7 billion lb, off about 10% from 1979. Optimists in the industry put 1980 production at 7.2 billion lb.

The optimists' reasoning comes from a closer look at available production statistics and current sales reports. During the first half of 1980, production of low-density polyethylene reached 3.7 billion lb, according to figures compiled by Ernst & Whinney for the committee on resin statistics of the Society of the Plastics Industry. Although it is true that year-to-year production dropped greatly as the first half closed—more than 30% in June alone, for example—and that sales fell even faster, the cumulative drop for the first half was tiny.

Then in July, production increased over June. Sales also increased, by a larger amount, indicating that inventories are being drawn down. Although statistics are not yet available for more recent months, production has risen. More important, sales are rising even more. Because of this improving tone in the marketplace, some industry analysts expect more than 7 billion lb production in 1980.

Some of the current profitability slump in low-density polyethylene might have been avoided if producers had sensed a changing market faster this spring. They might have slowed production sooner and less drastically than they actually did once inventories bulged. For example, in May sales were 133 million lb, about 22% of production of 615 million lb.

In June, when the production slashes peaked, output ran at an annualized rate of 5.5 billion lb. This put the operating rate for the industry at 63% of nameplate plant capacity, not a highly profitable level. Capacity was 8.7 billion lb per year in first-quarter 1980.

Things will not be this bad for the whole year. The average operating rate for 1980 probably will exceed 80%, quite good compared to other thermoplastics. Next year, with some capacity increases and an expected return to production volume of 7.7 billion to 7.8 billion lb, the operating rate could average 85% of first-quarter nameplate capacity of 9.0 billion lb.

For the future, operating rates increasingly will be affected by expansion of capacity to make the new linear low-density polyethylene. As yet capacity for this material is a small part of the total. However, such capacity may grow rapidly as polyethylene producers decide that this kind of material has both the physical properties desirable in various markets, particularly film, and attractive production economics because of the lower process pressures required compared to conventional low-density polyethylene. As polymer development comes along, long-term capacity expansion could be practically all in the new linear type.

Again as with other thermoplastics, the recession will not have much of an impact on the end-use pattern for low-density polyethylene. Film will continue to dominate with upwards of two thirds of the total but probably not above 70%.

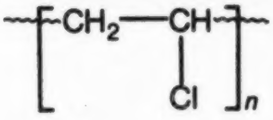
Exports have risen 11% this year to become the second largest outlet at about 1 billion lb. Later, exports probably will decline for the same reason affecting other plastics—reduced competitiveness of U.S. producers as they face higher raw material hydrocarbon costs.

Low-density polyethylene's export support has helped stave off an even worse financial performance. Its export volume (in pounds) is more than 40% greater than that of the next highest thermoplastic, polypropylene. And only polypropylene's exports are a greater percentage of total production, 20%, to low-density's 14%. High-density polyethylene also has enjoyed a 14% export level this year, but its export growth has stopped.

If improvements continue from the June low point in demand for low-density polyethylene, 1980 will turn out not too bad for a recession year. It could have been better, but low-density polyethylene has been spared the worst problems of other thermoplastics.

Key Polymers

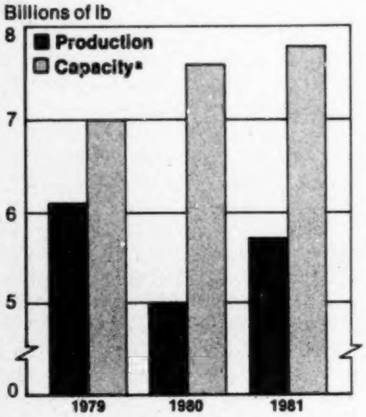
Polyvinyl chloride



$$\left[-CH_2-\underset{Cl}{\underset{|}{CH}}- \right]_n$$

- ***Demand awakening***
- ***Capacity rise slowing***
- ***Prices down***

PRODUCTION/CAPACITY



a Nameplate, first quarter.

HOW MADE

Polymerization of vinyl chloride by suspension, emulsion, or mass processes using initiator such as peroxide.

MAJOR FABRICATED FORMS

Extrusions, largely pipe, 60%; calendered sheet and film 10%; coatings 10%; molding 10%

FOREIGN TRADE

Exports—rising sharply to 450 million lb in 1980, imports—negligible

PRICES

Contract price for general-purpose resin 31 cents a lb, discounting continues

COMMERCIAL VALUE

$1.75 billion for total production, 1980

Of the major thermoplastics, polyvinyl chloride seems likely to post the worse percentage production decline in 1980. The impact of this decline also is clearer for polyvinyl chloride than for other thermoplastics. No other polymer is as rife with reports of major producers' selling or trying to sell their facilities. In all, it has been a stunning reversal from a year ago.

Unless recovery from the recession goes much faster in the fourth quarter than now anticipated, production of polyvinyl chloride in 1980 will drop to about 5 billion lb, off 18% from 1979. This drop comes when capacity is nearly 10% higher than a year earlier at 7.6 billion lb in first-quarter 1980.

Polyvinyl chloride's woes show up clearly in its wobbly price structure. The resin's notoriously tough customers in its major market, construction pipe, have helped force down the basic list price to 31 cents a lb from 35 cents a year ago. No other major thermoplastic has had an actual net decline in list price over the past year.

Excluding a small amount of new capacity which has started up or will start up in 1980, production of 5 billion lb will give an average plant operating rate of about 65% for the year. This rate contrasts strongly with 1979, when plants ran over 85% of nameplate capacity. This year's rate also contrasts strongly with rates before 1978, which were so high, often above a comfortable rate, that new investment was almost lavish.

These capacity expansions have hurt in 1980 and will continue to hurt in 1981. Production of polyvinyl chloride next year probably will fall short of 1979 production at least 5%, possibly as much as 8%, by pessimistic forecasts. This year, additions to capacity will be about 200 million lb unless some capacity is shut down permanently. If 1981 production of polyvinyl chloride rebounds about 15% to about 5.7 billion lb—a big improvement in view of widespread opinion that U.S. economic recovery will be slow--and capacity reaches 7.8 billion lb, the operating rate will rise to 73%.

Two years of plant use rates well below traditional levels plus the possibility of a third have caused company managements to take a second look at their investment in polyvinyl chloride. Some, including Air Products and Diamond Shamrock, have decided to unload the plastic if possible.

Firestone Tire & Rubber's sale of its polyvinyl chloride business to Occidental Petroleum for about $200 million (C&EN, Sept. 22, page 7) is the first major exit. Occidental got about 700 million lb of annual capacity for this money, paying under 30 cents per lb of annual capacity—perhaps not a great bargain, but a good value.

Occidental has about 200 million lb of other polyvinyl chloride capacity but is not a producer of monomer, vinyl chloride. Its subsidiary, Hooker Chemical, produces chlorine, which could give the company some leverage in buying the monomer.

At this time, partly because of the slump in demand for polyvinyl chloride, chlorine and caustic soda have divergent production trends. Coproduct caustic soda prices are rising because of a supply crimp from a lack of chlorine demand. Chlorine producers, several of which are vinyl chloride producers, are pushing use of both chlorine and vinyl chloride in the polymer.

All this has led to added downward pressure on selling prices for polyvinyl chloride in addition to pressure from recessionary demand. As with other major thermoplastics, profitability in polyvinyl chloride probably is marginal. Renewed price increases as a result of higher hydrocarbon costs are as likely as in other thermoplastics but may not be so large in the next few months, since vinyl chloride is more than half chlorine by weight. Chlorine prices have been held down.

To some in the polyvinyl chloride business, the future seems one of overcapacity with demand growth holding in the 5 to 8% annual range over the next five years. In other words, regaining 1979's 6.1 billion lb annual production rate will take well into 1982.

Maturing end uses such as the very large market in pipe will hold PVC growth rates down. Outside factors such as rising interest rates' impact on housing could pull down even a conservative growth rate, making polyvinyl chloride a product to shun for new investment.

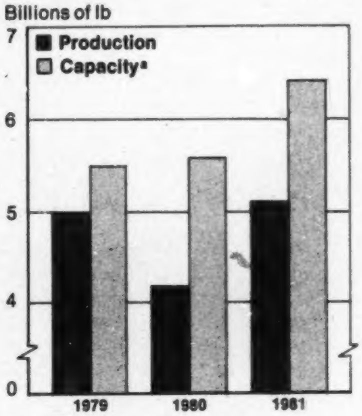
Key Polymers

$$-\!\left[\mathrm{CH_2}-\mathrm{CH_2}\right]_n\!-$$

High-density polyethylene

- ***Demand turning up***
- ***Capacity rising***
- ***Price slide past***

PRODUCTION/CAPACITY



[a] Nameplate, first quarter.

HOW MADE

Polymerization of ethylene under moderate pressure catalyzed by metal salts and alkyls

MAJOR FABRICATED FORMS

Blow molding, mainly containers, 45%; injection molding 20%; extrusions 10%; film 5%

FOREIGN TRADE

Exports—holding at about 600 million lb in 1980, imports—negligible

PRICES

Contracts about 45 cents per lb for common grades, discounting continues

COMMERCIAL VALUE

$1.75 billion for total production, 1980

High-density polyethylene joins other thermoplastics in a bad year in 1980. Production is off. Capacity will be or has been expanded when not really needed. Profitability will be marginal.

These conditions for 1980 represent a greater change for high-density polyethylene producers than for producers of most other plastics. For example, in 1979, producers generally struggled to meet demand for high-density polyethylene. Operations ran at more than 90% of the nameplate plant capacity of 5.5 billion lb at the beginning of the year. A few grades of the material were put on semiallocation.

Sales fell off drastically toward the end of the second quarter of 1980. Production also was cut back and has been held down during the summer as sales struggled along 20 to 25% below year-earlier levels.

But as with low-density polyethylene, sales and production of high-density material are beginning to recover. Some producers think that recovery will be better than expected, so the consensus forecast of 4.2 billion lb of production for 1980 may prove too low. If production doesn't do better than 4.2 billion lb, the decline will be one of the largest for thermoplastics at 16% from 1979.

Not much capacity came on stream for high-density polyethylene in 1979. Even so, with the production falloff this year, the plant operating rate could sink to 75% of nameplate capacity of 5.6 billion lb as of the first quarter.

Unfortunately, in 1979 and earlier, high-density polyethylene developed a reputation for supply tightness. This impression led to a round of plant expansions and shifts of capacity to high-density from low-density polyethylene production. The result has been 800 million lb per year of high-density capacity added, although not necessarily needed, in 1980. Therefore in 1981, even with full recovery of production to the 1979 level of 5.0 billion lb, plants will be operated at less than 50% of nameplate capacity.

A return of high-density polyethylene to 90% or higher levels of plant operation now seems unlikely for some time as a result of the recession and plans for further capacity expansion. After the recession is over, demand growth in high-density polyethylene could get back to 10% a year for some years, say optimists. But their mood is tempered by an even faster rate of capacity expansion, which will keep operating rates lower than in the recent economic expansion.

The end-use pattern for high-density polyethylene is not expected to change much. Some areas will not expand or will expand only slowly. For example, exports, forecast flat this year at about 600 million lb, probably will decline from now on, as U.S. production loses some of its marked raw material cost advantage of the past few years.

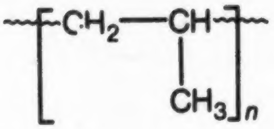
Few in the industry doubt that blow molding will continue to be the largest use of high-density polyethylene for some years ahead. The consumer container market has grown enormously to a level considered mature in some instances. However, high-density polyethylene is gaining new uses in blow-molded containers by replacing glass and metals as well as other plastics.

Other smaller uses could have large growth rates. For example, high-density polyethylene film is moving into many specialized packaging uses because of appearance and strength properties. The main drawback in film use, from resin producers' point of view, comes from the relatively large unit volume of finished product obtained per pound of resin in contrast to blow-molded items.

The pipe market, a part of the extrusions category, also could grow substantially. Competition comes in some pipe areas from low-density polyethylene. However, for the more severe industrial applications, pipe made from high-density polyethylene gets the nod over low-density.

Many uses of high-density polyethylene get competition from polypropylene, especially if cost differences are more important than are processing or property differences. This competition has been around some time and may have affected polyethylene's growth, but it never has done that much to slow high-density product development. If anything, such competition could be a stimulus to product development. This in turn could allow high-density polyethylene to recover from its 1980 decline better than will some other thermoplastics.

Key Polymers

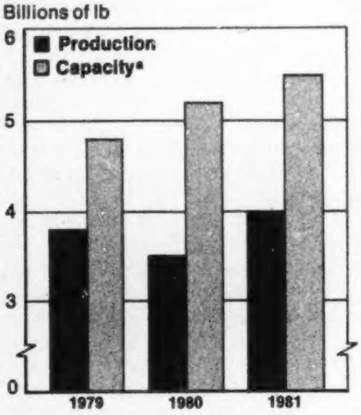


$$\left[-CH_2-\underset{CH_3}{\underset{|}{CH}}- \right]_n$$

Polypropylene

- ***Demand nosing up***
- ***Capacity up slightly***
- ***Prices weak***

PRODUCTION/CAPACITY



a Nameplate, first quarter.

HOW MADE

Polymerization of propylene catalyzed by metal salts and alkyls

MAJOR FABRICATED FORMS

Injection molding, much for transportation use, 40%; fibers 30%; film 10%

FOREIGN TRADE

Exports—may rise slightly to 700 million lb in 1980, imports—negligible

PRICES

Contract price for standard resins 36 cents per lb, spot prices lower

COMMERCIAL VALUE

$1.25 billion for total production, 1980

Polypropylene, like other thermoplastics, will not have a good year in 1980. Its difficulties strictly in terms of production could be less than for other thermoplastics. However, profitability will be marginal at best, since the business is not really in good shape.

Production of polypropylene in 1980 could be off less than for other plastics, perhaps down 8% from 1979 to about 3.5 billion lb. In so doing, polypropylene output has overtaken that of polystyrene this year.

So far, cumulative polypropylene production has been off less than 8%, but sales have slumped more. More severe recent slashes in production suggest that inventories are being cut to at least the level of monthly sales, if not lower.

Polypropylene's deeper problems also are hinted in the resin's basic list price, which at 36 cents a lb is up just a penny over a year ago. This price has been battered with heavy discounting this year, much of it due to polypropylene's bulging unused plant capacity.

Next year will be very "iffy" for polypropylene. U.S. demand in various end uses from automobiles to furniture to packaging all hinges on the outcome of the current recession. Even exports will be affected by recessionary economics in competing export nations as well as in foreign importing nations.

One widespread scenario for 1981 polypropylene production looks like the reverse of 1980. In 1980, production of polypropylene did well during most of the first half, then slumped during the summer. For the rest of 1980, production may continue well below 1979 but probably not so low as in July 1980.

In the first half of 1981, production may continue below most of the first half of 1980, especially if the apparent recovery from the recession slows down. Later in 1981, if the economy improves and consumer demand pressure builds, polypropylene production will increase to above the early 1980 levels.

In this view, second-half 1981 production will be the key to the whole year for polypropylene. Unless the second half is good, 1981 production will be lucky to match 1979 production.

Obviously, neither plant capacity nor raw material supply will have much influence on polypropylene production. New capacity additions now are slowing drastically as the last round of old expansions gets on stream.

The slowdown in capacity expansion unfortunately is only part of the needed remedy. With production down this year, capacity use will decline to just over two thirds of nameplate capacity of 5.2 billion lb available as the year began. The several relatively small capacity additions in 1980 will pull capacity use down to a lowly 65% for an annual average.

Not much improvement will occur in 1981 for capacity use. At best, polypropylene capacity will increase only a little more than the production increase expected for the year. If the optimistic view on production turns out high, then capacity use will remain well below 70%.

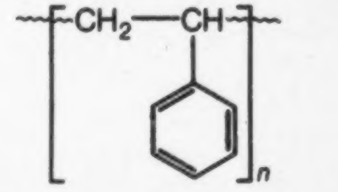
The recession is not expected to have much effect on the use pattern of polypropylene, just as past recessions have had little lasting effect. Of the various use categories, exports may be the one to decline next year. Cost competitiveness of U.S. polypropylene producers may fall in world markets because of increased costs of hydrocarbons in the U.S. relative to costs in other producing areas.

Increasing hydrocarbon costs—which mean that raw material polymer-grade propylene prices are not being forced down so much as are polypropylene selling prices—put polypropylene profitability on the skids. Currently, many industry sources doubt that polypropylene producers generally are making a profit when all costs are considered. So far, no capacity actually has been shut down, since all producers are part of strong companies that can stand the profit squeeze for a while.

The profit squeeze is undoubtedly causing much re-evaluation of new investment in polypropylene. Certainly, long-term capacity expansion forecasts have been put on hold. For if demand growth in polypropylene falls in the 5 to 8% range now widely expected, four to five years will be needed to reach full use of capacity, including capacity due to come on stream in 1981.

For the moment the word is, leave your polypropylene expansion money in the bank for a much better return. The plants themselves won't measure up for some time.

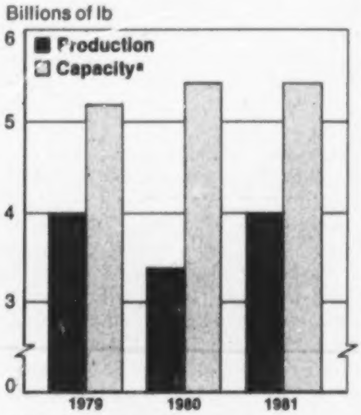
Key Polymers



Polystyrene

- ***Demand slump easing***
- ***Capacity flat***
- ***Price rise possible***

PRODUCTION/CAPACITY



[a] Nameplate, first quarter.

HOW MADE

Polymerization of styrene using peroxide initiator

MAJOR FABRICATED FORMS

Injection molding 50%, extrusions 30%, foamed beds 10%, one third of end markets in packaging

FOREIGN TRADE

Exports—rising to about 200 million lb in 1980, imports—negligible

PRICES

Contract, after allowances of generally 3 cents, 43 cents a lb for general purpose; discounting lessening but still widespread

COMMERCIAL VALUE

$1.5 billion for total production, 1980

Polystyrene producers are a troubled lot. Their problems this recession year are similar to other thermoplastics producers' but perhaps a bit more severe. Polystyrene already was the poor cousin of thermoplastics in the late 1970's.

Production of polystyrene in 1980 is forecast at about 3.4 billion lb, down 15% from 1979 production. This 1980 estimate may be too high, for during some summer months production was off 30% or more from 1979.

Recovery in 1981 could be fairly strong, equal to the 1980 decline in volume and higher percentage wise from volume at the end of 1980. Good second-half production likely will bring 1981 production to about the 1979 level.

Fortunately, no sizable plant capacity additions are expected for the rest of 1980. As of now, capacity additions next year are expected to be small, possibly less than 5% of first-quarter 1981 capacity of 5.4 billion lb. This capacity figure is unchanged from first-quarter 1980.

Polystyrene capacity, however, can change rapidly. How much capacity is really operable often is open to argument. Currently some capacity is shut down, so a simple estimate, based on total capacity, of 63% for the plant operating rate in 1980 could prove too low.

Some of the shut-down capacity may never be restarted. Still, debottlenecking (making small additions) to capacity is relatively easy, and small new plants can be built in a relatively short time and fed purchased styrene. In other words, polystyrene capacity can adjust fairly fast to changing demand.

Some of the small plants now shut down may be restarted in 1981. However, the operating rate still may climb back over 70%, perhaps near 75%, since capacity may drop a net 100 million lb because of plants permanently shut down.

Even so, a 75% operating rate means continued tough times for polystyrene producers. At this level, producers as a group are probably just marginally profitable. Much depends, of course, on bookkeeping—how much producers get back after temporary voluntary allowances, other discounts, freight costs, and styrene costs.

As of the end of September, downward pressure on polystyrene prices remained heavy but possibly a little less than at the beginning of the month. The tug for sales still is keen. Production cutbacks are beginning to ease the inventory problem, but as the fourth quarter opens, costs of carrying inventories still are high.

As they wrestle with selling competition, polystyrene producers are looking over their shoulders at styrene prices, heavily discounted through temporary voluntary allowances. They also look further up the chain at benzene, ethylene, and basic hydrocarbon prices. For a while, benzene and ethylene prices had been falling, leading to the allowances.

Now, benzene prices are firming, partly because of shifts in demand in oil refiners' gasoline pools toward even higher octane components using aromatics for unleaded gasolines. If prices of these basic chemical materials rise, little doubt exists that polystyrene's present allowances will come off fast as producers try to minimize their absorption of cost increases.

Too fast a rise in polystyrene prices could have the usual undesirable long-term impact—a shift by consumers to other resins, particularly polyolefins, which have nearly as good properties at a lower price. Resin price competition is behind the slightly slower growth in some polystyrene uses in recent years. Final products with not too critical properties such as many consumer semidurables—housewares, toys, or appliance components, for example—could let fabricators shift to other polymers and get something "almost as good" which they think would sell for the same price.

The end result of such price competition is slower overall growth for polystyrene. Combined with growth from new uses of about 5% a year and with a normal bounce-back in large markets now in recession, such losses would put polystyrene production in 1981 about equal to 1979.

After the first postrecession recovery, expansion of polystyrene demand in new and old uses will be slow. This will keep the cloud over polystyrene's profitability, hold down new investment, and raise polystyrene's low plant operating rate.

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Poll suggests public support for chemists

Chemists and chemistry come out quite well in a public opinion survey recently carried out for the American Chemical Society. However, the survey is very limited, involving just four questions. So any conclusions should be drawn with considerable caution.

But the data do indicate that there is wide public agreement that chemists have made significant contributions to the field of medicine. It also is apparent from the results that the public believes quite strongly that chemistry has produced more desirable than undesirable results.

The survey was conducted by Caravan Surveys, division of Opinion Research Corp., of Princeton, N.J. It involved personal interviews with 2052 men and women, 18 years of age and older, living in private households in the continental U.S. The survey sample was designed and the responses weighted so that the final

Responses to four questions break down this way

When you think about science, what fields of science come to mind?

Medicine	40.5%
Chemistry	27.0
Aerospace	16.8
Biology	15.3
Other	45.9
Don't know	13.9
Total	159.4%

Chemists have made significant contributions to the field of medicine.

Strongly agree	67.8%
Tend to agree	24.5
Tend to disagree	1.7
Strongly disagree	0.6
Don't know	5.4

Everything considered, the science of chemistry has produced more desirable than undesirable results.

Strongly agree	46.3%
Tend to agree	35.5
Tend to disagree	7.2
Strongly disagree	2.8
Don't know	8.2

When problems with chemicals are identified, which one group in society do you believe is most to blame?

Manufacturers	32.3%
Government regulations	22.4
Chemists	10.0
Businessmen	7.2
Elected politicians	5.8
Public at large	5.8
Engineers	2.6
Don't know	13.9

results may be projected for the total U.S. population 18 years and older.

The first question asked those polled to identify the fields of science that come to mind when they think about science. Multiple answers were allowed. According to Caravan, this question revealed that the public is hard pressed to name fields of science on an unaided basis.

The most frequently identified science was medicine, named by 40.5% of the weighted sample. Chemistry was second at 27.0%, aerospace third at 16.8%. Chemistry was more frequently identified by the younger generation—by 35% of those between 18 and 29, only 16% of those 60 and older. And chemistry's visibility apparently increases with education. It was named by 43% of college graduates, 17% of those who did not finish high school.

Reaction to the statement "Chemists have made significant contributions to the field of medicine" was almost uniformly positive. Of the total weighted sample 92.3% either strongly agreed or tended to agree. Blue-collar workers and those from low-income families—less than $7000 per year—were a little less positive. However, agreement did not fall below 80% for any subgroup.

With this strong recognition of chemistry's role in medicine, it is not surprising that reaction to the next statement "Everything considered, the science of chemistry has produced more desirable than undesirable results" also was quite positive. Of the total sample, 81.8% agreed with it, 10.0% disagreed, and 8.2% did not know. Again agreement was stronger among the better educated and more affluent.

Results from the fourth and last question—"When problems with chemicals are identified, which one group in society do you believe is most to blame?"—are the most difficult to interpret. Manufacturers come out highest on the list at 32.3% with government regulators second at 22.4%, chemists third at 10.0%, and businessmen fourth at 7.2%.

It is not clear what those who answered this question understood "manufacturer" to mean, and especially how it related to "businessmen" and "chemist." A manufacturer is a combination of management, sales, and other front office personnel, including "businessmen"; technical personnel, including "chemists"; and production workers. It also would be interesting to find out why government regulators rated so high. Is it because the public sees regulations as inhibiting chemical operations? Or is it because regulations are perceived as inadequate? □

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Congressional Elections '80

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News of the Week

- ***Research ties*** *between industry and academe cemented by University of Massachusetts, Amherst, 13 corporations, and NSF in program for polymer research.* ***Page 4***
- ***Chlorofluorocarbons production*** *will be limited to current levels under rules to be issued by EPA.* ***Page 4***
- ***Maytansine,*** *cancer drug whose toxicity dose is more than 100 times as great as its therapeutic dose, has been synthesized by Harvard University team.* ***Page 5***
- ***Union Carbide will build*** *$150 million silicones plant of unspecified capacity at its South Charleston, W.Va., site.* ***Page 5***
- ***Killing cancer cells in the body*** *by directing antibodies to deliver highly radioactive iodine to the protein of tumor cells tested at Johns Hopkins.* ***Page 6***
- ***U.S. chemical companies*** *will retain their hydrocarbon raw material cost advantage over foreign firms through the early 1980's, consultant predicts.* ***Page 6***

Business

- ***U.S. chemical plant capacity use is down*** *to 66% from 81% a year ago as a result of an overall drop in production and a small gain in capacity.* ***Page 9***

International

- ***European chemical company executives*** *blame their own actions as well as those of the U.S. for declining profits, point up need for cooperation.* ***Page 11***

Government

- ***Congressional elections for 1980*** *could have far-reaching effects in Congress as a whole, and specific interest for the chemical community.* ***Page 14***

Science

- ***How photochemical systems transfer energy*** *studied using rigid molecules and single photon counting technique.* ***Page 18***

Technology

- ***Shunt currents,*** *which lower efficiency of electrochemical devices, can be eliminated by passing a separate current through the electrolyte.* ***Page 20***
- ***U.S.S.R.'s underground coal gasification*** *program, promising in the 1950's, has failed to meet expectations.* ***Page 21***
- ***Composite catalysts allow comethanation*** *of carbon monoxide and carbon dioxide in mixtures with hydrogen.* ***Page 21***

ACS News

- ***American Chemical Society plans*** *a series of seminar/workshops on lab and plant safety beginning Oct. 27.* ***Page 23***

Books

- ***Two recent books*** *indicting nuclear power technology's threat to health, safety, and freedom are reviewed and found biased and misleading.* ***Page 29***

Chemical capacity use down to 66%

A 9% overall production drop combines with 6% capacity gain to bring down use of U.S. chemical plant capacity sharply from 81% a year ago

William F. Fallwell,
C&EN New York; Bruce
F. Greek, C&EN Houston

Polymers' capacity use drops hard in thermoplastics

Billions of lb	Third-quarter 1980			Third-quarter 1979		
	Capacity nameplate	Capacity use		Capacity nameplate	Capacity use	
		Nameplate	Effective		Nameplate	Effective
Plastics						
Polyethylene, low-density	9.0	62%	67%	8.5	92%	99%
Polyvinyl chloride	7.8	49	57	7.1	87	101
Polyethylene, high-density	6.2	58	61	5.5	95	100
Polystyrene	5.4	48	56	5.3	74	86
Polypropylene	5.4	52	58	5.0	80	89
Synthetic fibers						
Filament yarn						
Polyester	2.1	64	68	2.1	78	83
Nylon	2.1	64	68	2.0	85	90
Olefin	0.93	67	71	0.94	66	70
Staple						
Polyester	2.7	92	98	2.6	92	98
Nylon	1.0	77	82	1.0	91	97
Acrylic	0.85	83	88	0.85	84	89
AVERAGE		**65%**	**70%**		**84%**	**91%**

Sources: Industry sources, Textile Economics Bureau, Society of the Plastics Industry, C&EN estimates

After showing the first cracks amid a generally high performance at the end of 1979 (C&EN, April 14, page 11), capacity use at U.S. chemical plants sank like a stone in the first half of 1980.

At the beginning of the third quarter, overall production in 30 leading chemicals surveyed semiannually by C&EN was down to an unweighted average of 66% of nameplate capacity. Use of effective capacity declined to 72%. These levels could be the low point of the recession, since production seems to have firmed up since then.

These figures represent a breathtaking drop from the industry's profitable 81% overall use of nameplate capacity in third-quarter 1979 and at the turn of the year. Effective capacity use in these 30 chemicals was 88% both times.

Behind the capacity use averages lie two contributing factors. Plant capacity for these 30 chemicals combined rose 6% over the past year to a total of 512 billion lb. This expansion hurt as production dropped 9% to an annual rate of 362 billion lb. The result is the 66% capacity use rate early this summer.

For downstream polymers, the news is even worse. For a total of 11 thermoplastics and synthetic fibers surveyed by C&EN, use of combined nameplate capacity dropped to 65% in third-quarter 1980 from 84% a year ago and 83% at the end of 1979. Effective capacity use in polymers was 70% this summer compared to 91% a year ago and 89% at the end of the year.

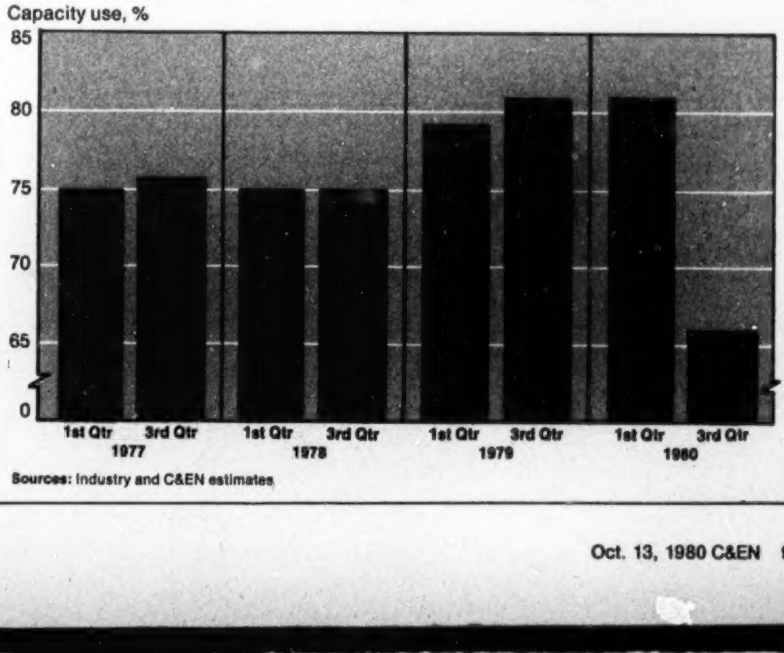
In the polymers, nameplate plant capacity also rose 6% over the past year to a total of 43.5 billion lb. Meanwhile, output fell 27%, leading to the big drop in capacity use.

C&EN's overall findings in the production collapse of these polymers and chemicals agree closely with government production indexes over the past year. For example, the Federal Reserve Board figures show a 9% drop in the production index for basic chemicals from July 1979 to July 1980, and a 28% drop in polymers.

The government has no corresponding capacity or capacity-use figures. Although it can't be a surprise that capacity has gained somewhat and capacity use has slumped, the exact extent of both changes can be found only in a product-by-product analysis with the extensive help of industry sources.

Such a product run-through discloses an astonishing range of plant

Nameplate capacity use is way down from early 1980



Sources: Industry and C&EN estimates

Plant use drop from 1979 runs nearly across the board

Billions of lb per year unless otherwise noted[a]	Third-quarter 1980			Third-quarter 1979		
	Capacity nameplate	Capacity use		Capacity nameplate	Capacity use	
		Nameplate	Effective		Nameplate	Effective
Oil-based petrochemicals						
Ethylene	40.0	63%	70%	36.5	89%	99%
Propylene (chemical)	23.7	48	53	20.5	72	80
Butadiene[b]	4.0	65	72	4.0	90	100
Benzene (bg)	2.4	64	70	2.3	77	84
***p*-Xylene**	5.6	68	72	5.7	79	88
Natural gas-based petrochemicals						
Methanol (bg)	1.4	80	89	1.4	85	94
Formaldehyde (37% solution)	8.6	59	62	9.1	74	78
Ammonia (mt)[c]	24.0	75	79	20.4	91	96
Urea (mt)[c]	8.0	91	101	7.5	87	97
Chlor-alkalies						
Chlorine (mt)	14.6	69	73	14.4	88	93
Caustic soda (mt)	15.3	68	72	15.1	85	90
Soda ash (mt)	9.7	79	83	9.1	92	97
Acids						
Sulfuric (mt)	58.0	76	80	56.0	81	85
Phosphoric (P_2O_5, mt)	11.7	87	92	9.8	94	99
Industrial gases						
Oxygen **Nitrogen** } (total, liquid, ttd)	33.6	69	85	31.2	67	83
Carbon dioxide (ttd)	15.6	68	77	12.5	52	62
Mineral-based inorganics						
Sulfur (Frasch, mlt)	14.5	72	—	14.1	76	—
Phosphorus (mt)	0.55	70	74	0.55	78	85
Plastics monomers						
Styrene	8.9	55	58	8.4	89	94
Vinyl chloride	8.2	63	70	8.4	99	109
Propylene oxide	2.7	48	53	3.0	83	92
Fiber monomers						
DMT/PTA[d]	7.3	59	69	7.3	81	95
Ethylene oxide	6.6	70	78	6.5	78	82
Cyclohexane	3.4	52	55	3.2	78	83
Adhesives and coatings monomers						
Phenol	3.7	65	72	3.5	80	89
Vinyl acetate	2.5	68	72	2.4	83	87
Pigments						
Carbon black	3.7	61	68	4.3	73	85
Titanium dioxide (mt)	1.0	66	73	0.88	88	98
Solvents						
Ethanol (mg)	270	69	73	270	74	78
1,1,1-Trichloroethane	1.3	44	49	1.1	55	61
AVERAGE		**66%**	**72%**		**81%**	**88%**

[a] bg = billions of gal, mt = millions of tons, ttd = thousands of tons per day, mlt = millions of long tons, mg = millions of gal. [b] Based on extraction capacity of steam-cracking plants and dehydrogenation capacity only of dehydrogenation producers; could be more if extraction capacity of dehydrogenation plants were included. [c] Some capacity probably still shut down, less than 15% for ammonia and less than 5% for urea. [d] Dimethyl terephthalate plus purified terephthalic acid, not including acid converted to DMT. **Sources:** Industry and government sources, C&EN estimates

C&EN's capacity use indicator—the ground rules

Capacity use at chemical plants is difficult to measure and requires certain assumptions to bring some order to the maze of variables affecting this critical indicator of the industry's health.

With the help of industry and government sources, C&EN measures capacity use as a percentage of both nameplate and effective maximums. Nameplate capacity is the official design capacity of plants at nonstop use all year. Effective capacity is the practical maximum capacity after reductions for regular maintenance shutdowns and changes in product mix. Effective capacity runs from 85 to 95% of nameplate for most chemicals.

Capacity use is given semiannually over a calendar quarter, with no seasonal adjustment. The figures include plants actually running. Figures exclude new plants just starting up and old plants knocked out for long periods by accidents or mothballing. As much as possible, capacity figures stay current with expansions and debottlenecking.

Capacity figures do not take into account temporary fluctuations for fuel and electric power interruptions, equipment failure, and feedstock scarcity or substitution. The feedstock variables were especially important in 1979, further reducing maximum output for a number of important products.

Products in C&EN's capacity use survey are the same as those in the Key Chemicals and Key Polymers series. These are the core products of the industry, the basis for downstream production of thousands of more specialized products.

use levels in various areas. In third-quarter 1980, nameplate capacity use in chemicals ran all the way from 91% in urea to 44% in 1,1,1-trichloroethane. In polymers, the range was from 92% in polyester staple to 48% in polystyrene.

A glance through various product groups shows that organics and downstream thermoplastics got the worst of it in this year's recession. By contrast, inorganics, especially those related to fertilizer, made it to the third quarter with much less damage.

The worst was certainly in basic petrochemicals and downstream plastics. The five basic olefins and aromatics in C&EN's survey suffered a combined production drop of 21% over the past year while capacity rose 9%. Nameplate capacity use this summer sank to 62% from 81% a year ago.

A look at thermoplastics, the biggest outlet for these chemicals, shows why. Thermoplastics output fell 32% in third-quarter 1980 from third-quarter 1979, while capacity climbed 8%. The result was that capacity use slid from 86% to 54%.

Among various inorganics, capacity use is more mixed. To start with a negative, the chlor-alkalies held up against the recession until the third quarter this year, but then took a dive. Production in chlorine, caustic soda, and soda ash was down 17% this summer from a year ago, while capacity edged up 3%. Capacity use fell to 72% from a robust 88% in third-quarter 1979.

On the other hand, the big-volume acids, sulfuric and phosphoric, enjoyed about the same production volume in third-quarter 1980 as last year's third quarter, but issuing from 6% more capacity. Such health, due largely to phosphate fertilizer exports, kept capacity use of these acids at 82%, compared to 88% a year ago. □

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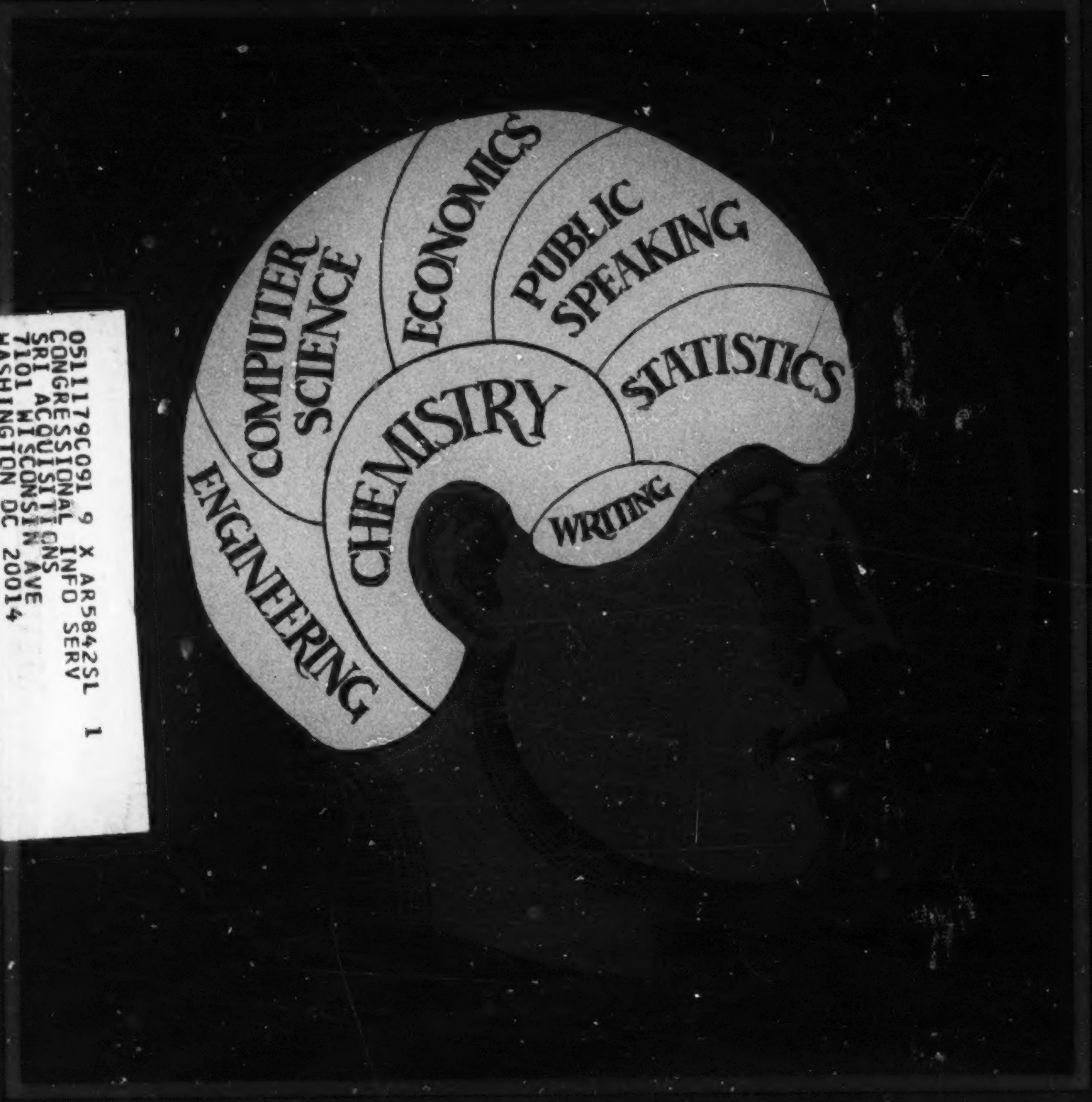
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What chemists need to know—besides chemistry

Employment outlook [illegible] Page 41

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News of the Week

- ***1980 Nobel Prizes in both chemistry and medicine*** *awarded for work in the field of genetic research; Nobel Prize in physics for work on the decay of K mesons.* ***Page 6***
- ***Mortality study conducted by Monsanto*** *of 163 deceased employees shows no apparent relationship between exposure to dioxins and deaths from a variety of causes.* ***Page 7***
- ***Third-quarter earnings*** *for chemical companies mixed with basic chemical firms having a rough time, those with energy or fertilizer operations doing well.* ***Page 7***
- ***Americans continue to support environmental protection*** *despite growing concern over other issues, Council on Environmental Quality study finds.* ***Page 8***
- ***First living coral reef community*** *to be isolated from the sea unveiled at Smithsonian Museum of Natural History.* ***Page 8***

Business

- ***Olin is increasing its emphasis on specialty chemicals,*** *shows signs of getting back on the growth track, says new president Ray R. Irani.* ***Page 18***

International

- ***Malaysian rubber-based industry*** *will play a key role in the government's effort to lure foreign manufacturing investment to the country.* ***Page 23***

Government

- ***Issue of risk assessments of new chemicals*** *tackled by Sixth Symposium on Statistics & the Environment, held by the National Research Council of the National Academy of Sciences.* ***Page 30***

Education

- ***Refresher course in organic chemistry*** *to debut in Florida; developed in England, course is aimed at updating chemists who have been out of school for some time on recent chemical advances.* ***Page 33***

Technology

- ***Innovative chemical heat pump*** *is based on reaction of methanol vapor and anhydrous calcium chloride allowing it to use solar energy to provide air conditioning as well as heating and hot water.* ***Page 36***
- ***Dyna-Sep microfiltration system*** *uses cross-flow filtration technique to prevent accumulation of solids on surface of membrane filter.* ***Page 38***

1981 Employment Outlook

Demand is relatively strong and salaries are up, *C&EN's annual look at job prospects for chemists and chemical engineers indicates. This year's feature includes a special report on what—other than science—chemists need to know.* ***Page 41***

DEMAND
1981

Chemists are in good demand, should have few problems getting jobs in 1981

Even though many segments of the economy suffered major setbacks this year, demand for chemists and chemical engineers held up well. And now that many economists believe that the nation's business health will begin to improve, job prospects for chemical professionals will more than likely continue to be good in 1981.

Two signs of strength: Unemployment among ACS members was lower in March 1980 than in March of any recent year, and the volume of "positions open" advertising in C&EN has been greater in 1980 than in recent years.

In the Employment Clearing House at the most recent ACS national meeting, the average number of job interviews per candidate was somewhat less than it was at the national meeting 12 months earlier. One reason may have been that the Las Vegas location of the meeting was less convenient for many employers than was the 1979 fall meeting in Washington, D.C.

Recruitment of graduating chemists and chemical engineers on several college campuses in academic year 1979–80 was more active than it was in 1978–79. Some schools report all-time highs for the number of employers who interviewed their graduating chemists or the number of interviews they had. College placement officers, moreover, generally are optimistic about the demand for their graduating chemical professionals in academic year 1980–81.

According to Peggy Dempsey, technical placement adviser in the Career Planning & Placement Center at the University of California, Berkeley, demand for both chemistry and chemical engineering graduates was unusually brisk in 1979–80, with 57 employers interviewing graduating chemistry students, compared to 43 in 1978–79. In addition, 114 employers interviewed chemical engineers, compared to 94 in 1978–79.

Many of these recruiters, Dempsey says, have been from the petroleum, electronics, aerospace, and food processing companies who have facilities on the West Coast. The nation's general economic slump appears to have had very little adverse effect on the demand of these employers for chemists and chemical engineers. She adds, "I have heard almost nothing from employers, except those in the automobile industry, to indicate a reduced demand for graduates in the physical sciences or engineering."

Dempsey believes that, on the basis of employer visits already scheduled, the recruiting activity for chemists and chemical engineers at Berkeley also will be good in the 1980–81 academic year.

The University of Illinois' school of chemical sciences, which covers both chemistry and chemical engineering, experienced unusually active recruiting in 1979–80, with student interviews reaching an all-time high.

Rebecca J. Simon, placement director at the school of chemical sciences, believes that this may be attributed to the current efforts of employers to catch up on their hiring of chemical professionals following the sharp cutbacks in the hiring of such employees in the mid-1970's. Employer recruiting visits increased from 192 in 1978–79 to 210 in 1979–80. The number of man-days that employers spent interviewing on campus rose from 309 to 425. Total student interviews climbed from 3631 to a record 4868. Because of their packed interviewing schedules and long working hours, she says, many recruiters felt they had "earned their salt" while on campus.

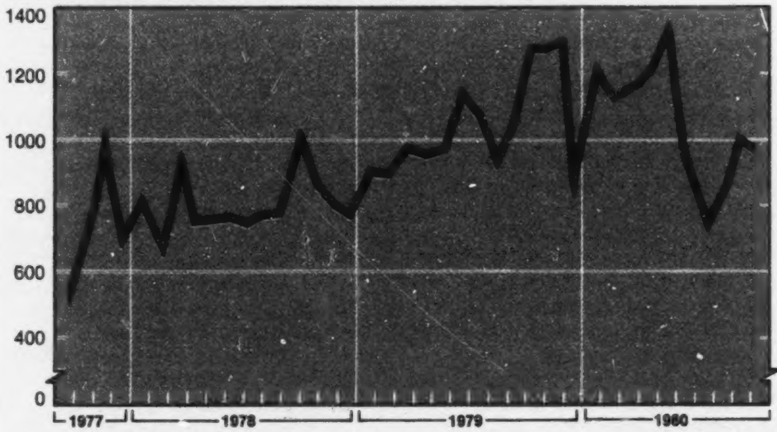
The outlook for the 1980–81 season, Simon says, is good. Only five or six employers have canceled interview visits requested earlier this year. These losses, which are normal, have been counterbalanced largely by several employers planning to interview students on campus who have never done so before or have not been seen for several years.

The number of organizations that interviewed graduating chemists at the University of Wisconsin rose from 76 in 1978–79 to a record 85 in 1979–80. Audrey L. Aylesworth, the university's chemistry placement coordinator, says that the average B.S. chemistry graduate in 1979–80 got about two job offers. The average M.S. chemistry graduate received about three offers, the average Ph.D. about three offers, and the average postdoctoral student about two offers. These figures are about the same as in 1978–79. On the other hand, in 1974–75, the typical Ph.D. graduate, for example, felt extremely fortunate with even one job offer.

Aylesworth noted almost no talk of a business recession among the company representatives who interviewed graduating chemistry students at Wisconsin. The chemists in exceptionally large demand, she says, were those with special training in polymer and petroleum chemistry. Some

Recruitment advertising breaks previous records

Volume of C&EN "positions open" advertising, column-inches[a]



[a] Total volume of "positions open" advertising in four consecutive issues of C&EN ending with the issue specified. No issues were published in the last week of December 1977, 1978, and 1979.

chemists, she adds, have been benefiting from the shortage of chemical engineers. She finds that some companies are hiring chemists to train them to become chemical engineers.

Aylesworth expects 1980–81 to be at least as good as 1979–80. "So far," she points out, "only one company has canceled its planned visit. Also, some companies intend to spend more time on campus interviewing chemistry students in 1980–81 than they did in the previous academic year."

As another measure of demand for chemists and chemical engineers, participation in the Employment Clearing House (ECH) at the ACS fall 1980 national meeting in Las Vegas was noticeably less than at the fall meeting in Washington, D.C., in 1979. Because more employer representatives and job applicants live east of the Mississippi than west of it, many probably found Las Vegas less accessible. No doubt, fewer employer representatives showed up in Las Vegas because they assumed that smaller numbers of job applicants would be on hand. Moreover, a few employer representatives decided not to go to the latest ECH when the meeting site was changed at almost the last minute from San Francisco to Nevada's gambling mecca.

To what extent, if any, the lower ECH figures for fall 1980 reflect a reduced demand for chemists is a matter of conjecture. Audra B. Rafter, manager of the ACS Employment Aids Office, which operates ECH, points out that the average number of interviews per job applicant was not markedly fewer at Las Vegas than in Washington. Partly from this, she concludes that demand for chemists during the past year has remained reasonably constant.

The number of employer representatives who used ECH at the Las Vegas meeting was 209, compared to 368 in Washington. Job applicants at Las Vegas numbered 356, down from 589. The positions listed at ECH for candidates' review totaled 375 in Las Vegas, compared to 536 in Washington. The total number of job interviews declined to 1165 from 2279 in Washington.

Perhaps the most significant finding was that the average number of interviews per candidate was 3.3 in Las Vegas, compared to 3.9 in Washington. The Las Vegas figure was considerably better than the disappointing 2.3 interviews per candidate reported by ECH at the fall 1975 national meeting in Chicago, a city far more accessible than Las Vegas to many chemical employers.

By far the greatest number of positions (87) listed at ECH in Las Vegas was for analytical chemists. This has been typical for many years, although the specialists in largest demand at the fall 1979 clearinghouse were polymer chemists.

Ranked below analytical chemists were organic chemists (52 openings), polymer chemists (43), biochemists (24), chemical engineers (21), and physical chemists (21). The number of openings for inorganic chemists (13) was relatively low, as is generally the case. The situation this year, however, was not nearly so bad as it was at the fall 1977 meeting, when ECH listed only two positions for inorganic chemists.

The U.S. Office of Personnel Management (formerly the Civil Service Commission) says that the federal government's hiring of chemists, which was unusually low in fiscal 1979 (ended Sept. 30), has since increased. The government hired 601 chemists in fiscal 1977, 475 in fiscal 1978, and only 292 in fiscal 1979. However, in fiscal 1980, the number rose to an estimated 400.

The government steadily has been increasing its hiring of chemical engineers. It hired 58 in fiscal 1977, 62 in fiscal 1978, 73 in fiscal 1979, and an estimated 80 in fiscal 1980.

These data cover chemical professionals in grades 5 through 15, excluding high-level personnel in the

Companies plan to step up hiring slightly

Chemists and chemical engineers looking for a job in industry are likely to find the market for their skills at least a bit stronger next year than it has been in 1980. But this improvement hardly will be robust, at least in comparison with some recent years. And many leading employers admit that their demand for chemists and engineers is difficult to predict, considering the current uncertainty about the near-term state of the economy. Employers are just about unanimous, though, in their opinion that employment prospects generally are good through the middle of the current decade for chemists, and probably even better for chemical engineers.

This, in any event, is the outlook as indicated by the latest of C&EN's annual surveys of the hiring plans of leading U.S. chemical employers. The survey covers 30 companies—mostly in the chemical industry but also from such related fields as petroleum, rubber, and drugs—that currently employ more than 15,000 chemists and 18,000 chemical engineers.

These companies will be building up their staffs of chemists and chemical engineers if only modestly, both this year and next. They employed 3% more chemists at midyear than they did at mid-1979 and plan to add another 3% by mid-1981. Their chemical engineers were up 5% during the 12 months ended last June and the number is expected to increase at the same rate during the current 12-month period.

This year, however, they are hiring 3% fewer chemists than they did in 1979 (a year when hiring was particularly strong). Next year, however, hiring plans for chemists are about on par with this year, may even be up slightly. As for chemical engineers, who had a considerably better year in 1979 than did chemists, industrial employers see a 2% cutback in hiring plans this year followed by a 2% increase in 1981, for a net standoff in new hires for the entire two-year period.

Most of these new employees will be fresh out of school. Nearly three fifths of the chemists expected to be hired this year and next will be new graduates; last year only half were. Two thirds of the chemical engineers hired last year had just been awarded their degrees; in 1980 and 1981, three fourths are expected to be new graduates.

In search of new graduates, companies are recruiting more vigorously at college campuses and universities. They made 13% more visits to campuses during the academic year 1979–80 to seek out chemists and 7% more visits looking for chemical engineers. During the current year, visits are likely to be at least as frequent as last year and even may increase slightly.

Most companies, too, are seeking chemists with specialized skills. As was the case last year, analytical chemists are in greatest demand, followed by organic, polymer, and physical chemists. Chemists with a background in biochemistry, catalysis, pharmaceutical chemistry, environmental chemistry, solid-state chemistry, or coal chemistry also are in demand.

Women, meanwhile, continue to make modest inroads among chemists and chemical engineers in industry. They accounted for 8% of the chemists employed by respondents to C&EN's survey in mid-1979 but 10% of the total in mid-1978; that percentage is not expected to change perceptively by mid-1981, however. Women also accounted for 3% of the companies' chemical engineers last year, increasing to 4% this year; next year they are expected to make up 5% of the total.

so-called "supergrades." Moreover, the data cover people only in about 80 federal agencies in the "competitive" civil service system, which does not include such "excepted" agencies as the Federal Bureau of Investigation, the Central Intelligence Agency, and Tennessee Valley Authority.

The total number of chemists working for the federal government is currently at almost the highest level in recent years. On board were 8025 chemists in October 1977, 8256 in October 1978, 8130 in October 1979, and an estimated 8250 in October 1980. The total number of chemical engineers working for the government was 1433 in October 1977, 1465 in October 1978, 1451 in October 1979, and an estimated 1475 in October 1980.

Looking beyond 1980, Harry L. Clark, a manpower analysis officer in the Office of Personnel Management, says, "There is a strong possibility of a substantial growth in the government's hiring of chemists and chemical engineers in the coming years. Much will depend on the extent to which Congress in fiscal 1981 and 1982 acts to expand chemical R&D in the fields of defense and energy."

An indication of the demand for new graduates in chemistry and chemical engineering (as well as in many other fields) is provided by data from the College Placement Council, Bethlehem, Pa., on job offers made to graduating students in a representative group of U.S. colleges and universities (now 164).

CPC figures show that candidates for B.S. degrees in chemistry received 13% more job offers in 1979–80 than in 1978–79. Inexperienced M.S. candidates for chemistry degrees received 28% fewer offers in 1979–80 than in 1978–79, but Ph.D. candidates received 25% more offers.

As for chemical engineering students, B.S. candidates received 11% more offers in 1979–80, inexperienced M.S. candidates got 23% fewer offers, and Ph.D. candidates got 44% more offers.

According to the latest CPC report, vastly more job offers in 1979–80 went to B.S. chemical engineering students (7029) than to B.S. chemistry students (427). This partly reflects the more intense demand for chemical engineering candidates than for chemists. It also reflects the higher percentage of B.S. chemical engineers who begin employment immediately after graduation; B.S. chemistry candidates frequently do not look for jobs because they plan to go on to advanced study.

The CPC findings indicate that the number of job offers to women candidates for B.S. degrees in chemistry is increasing more rapidly than those to men candidates. The number of offers that went to women was 24% higher in 1979–80 than in 1978–79, but the offers to men increased only 6%.

The total number of chemists and chemical engineers who are in the job market is affected greatly by the number who graduate each year. According to the Department of Education's National Center for Education Statistics, the number of people who received B.S. degrees in chemistry (excluding biochemistry and geochemistry) rose from 11,474 in 1977–78 to 11,643 in 1978–79. In the same period, the number of Ph.D. degrees awarded in chemistry declined from 1525 to 1518. The number of new Ph.D. chemistry graduates has decreased every year since 1969–70, when the total was 2208.

The number of bachelor's degrees awarded in chemical engineering reached a record high of 5655 in 1978–79. In the previous academic year, the figure was 4615. By comparison, 3557 B.S. degrees in chemical engineering were granted in 1968–69. Ph.D.'s in chemical engineering, which declined each year from 400 in 1973–74 to 259 in 1977–78, increased in 1978–79 to 304.

An American Chemical Society study of its members shows that, on March 1, 1980, only 0.9% of the chemists were unemployed but seeking employment. In recent years, the unemployment rate has been declining steadily. The proportion of ACS chemists who were unemployed but seeking employment was 1.5% on March 1, 1977, for example, and 1.1% on March 1, 1979.

The 0.9% unemployment rate for ACS-member chemists in March 1980 was, in fact, the lowest since the society began its employment surveys in 1971. The peak level of unemployment among member chemists was 3.2% in 1972.

Clearly, unemployment is much less of a problem among chemists than it is among the total civilian labor force. In the latter group, the unemployment rate was 7.4% in March 1977, 5.7% in March 1979, and 6.2% in March 1980.

Among B.S. chemists responding to the ACS survey, 1.4% were unemployed but seeking employment on March 1, 1980. At the same time, the comparable figures were 1.0% for M.S. chemists and 0.6% for Ph.D.'s.

The American Institute of Chemical Engineers reports that, as of February 1980, only 0.4% of its members were unemployed, as was true also in both February 1978 and 1979. Joblessness among AIChE members was decidedly greater in the early 1970's. For example, 3.7% of the members in mid-1971 were unemployed. The 1980 institute survey shows that the median length of time that a member remained jobless during the survey period was 11 months (a figure based on a very small sample), compared to three months reported in the 1979 study.

A useful barometer of how vigorously employers are looking for chemists and chemical engineers is the volume of "positions open" advertising in C&EN. The volume was greater during the 12 months between October 1979 and October 1980 than it was in the previous 12 months, which was an unusually good period.

During the first nine months of 1980, C&EN published 10,330 column-inches of help wanted advertising, 3% more than in the same period of 1979. The third quarter of 1980, however, saw a 17% drop in such advertising. Volume fell from 3493 column-inches in July, August, and September of 1979 to 2895 in the same months of 1980. □

More B.S. chemists and chemical engineers are graduating, but Ph.D.'s continue to decline

Academic year	Degrees awarded in chemistry[a]			Degrees awarded in chemical engineering		
	Bachelors	Masters	Ph.D.'s	Bachelors	Masters	Ph.D.'s
1968–69	11,207	2070	1941	3557	1136	409
1969–70	11,617	2146	2208	3728	1045	436
1970–71	11,183	2284	2160	3615	1100	406
1971–72	10,721	2259	1971	3663	1154	394
1972–73	10,226	2230	1882	3636	1051	397
1973–74	10,525	2138	1828	3454	1045	400
1974–75	10,649	2006	1824	3142	990	346
1975–76	11,107	1796	1623	3203	1031	306
1976–77	11,322	1775	1571	3581	1086	291
1977–78	11,474	1892	1525	4615	1237	259
1978–79	11,643	1765	1518	5655	1149	304

a Does not include biochemistry and geochemistry. Source: Department of Education's National Center for Education Statistics

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SALARIES
1981

Chemists are earning more, but inflation takes a heavy toll

Median salaries of experienced chemists increased 6% for those with B.S. degrees, 4% for M.S.'s, and 8% for Ph.D.'s between March 1979 and March 1980. Meanwhile, starting salaries of chemists fresh out of school rose 3% for B.S.'s, 18% for M.S.'s, and 15% for Ph.D.'s. (The apparent small increase for inexperienced B.S. chemists may be the result of sampling error in 1979.)

According to the Department of Labor's consumer price index, living costs climbed nearly 15% between March 1979 [illegible] March 1980. Hence, although the [illegible] salaries of experienced chemists increased in current dollars, they declined when inflation is taken into account.

These are among the findings of two annual salary surveys conducted by the ACS Office of Manpower Studies. One study, which covers the salaries only of ACS members, was issued in midyear as Salaries 1980 (C&EN, June 30, page 25). The other survey deals with the salaries of inexperienced chemistry and chemical engineering graduates (those with 12 months or less of professional experience), many of whom are not ACS members. The findings of this survey will be published in early November as Starting Salaries 1980.

More than 16,000 ACS members provided data for the 1980 salary survey of experienced chemists and chemical engineers. The study shows that the median annual salary of all B.S. chemists increased from $23,500 on March 1, 1979, to $25,000 on March 1, 1980. During the same period, the median annual salary of M.S. chemists rose from $25,000 to $26,000, and the median for Ph.D. chemists climbed from $29,000 to $31,200.

In addition, the survey indicates that the median annual salary of B.S. chemical engineers who are ACS members rose 10% from $31,700 on March 1, 1979, to $35,000 on March 1, 1980. During this period, the median for M.S. chemical engineers increased 11% from $31,500 to $35,000. And for Ph.D. chemical engineers, the median climbed 9% from $35,000 to $38,000. Thus at each degree level, not only do the chemical engineers have a higher annual salary than do their chemist counterparts, but their salaries showed a greater percentage increase between 1979 and 1980.

The American Institute of Chemical Engineers reports that the median annual salary of its members at all degree levels increased 5% from $29,500 in February 1979 to $31,000 in February 1980. Median salaries of AIChE members are less than those reported for ACS-member chemical engineers because, at least in part, members of AIChE tend to be younger and thus have less professional experience than do chemical engineers belonging to ACS.

Even though the median salary of all ACS-member chemists climbed a weighted average of 7% between March 1979 and March 1980, the increase in the consumer price index during this period was double that rate. Consequently, the median annual salary of chemists actually decreased in constant dollars about 7%, the largest decline in chemists' purchasing power in at least the past 25 years.

Chemists' salaries are influenced by the type of employer they work for. Ph.D. chemists, for example, received a median annual salary in March 1980 of $36,000 if they worked in private industry, $34,100 if in the federal government, and $25,000 if in colleges and universities.

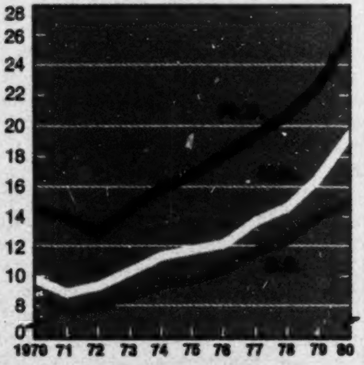
The type of industry a chemist works for also can affect his or her salary. In March 1980, the highest median annual salary paid to industrial Ph.D. chemists, for example, was the $38,850 received by those in the petroleum industry. Next in order were Ph.D. chemists in the pharmaceutical industry ($37,850), chemicals ($36,300), rubber ($36,150), paper ($35,000), metals ($35,000), coatings ($32,500), and food ($32,000).

Other factors affecting salaries are the position a chemist holds and his or her area of specialization. For Ph.D. chemists, the median annual salary in March 1980 was $43,000 for people in R&D management, $40,000 for those in general management, $39,000 in consulting, $38,000 in marketing, $32,900 in basic research, and $31,700 in applied R&D. The median salary of Ph.D. chemists specializing in polymer chemistry was $37,000, in pharmaceutical chemistry $36,000, in biochemistry $30,150, in organic chemistry $30,000, in analytical chemistry $29,600, and in inorganic chemistry $28,350.

One out of every 10 ACS members is a woman, and the data consistently show that women chemists, overall, receive lower salaries than men chemists. One reason is that women chemists tend to be younger than men chemists. The median age of women belonging to ACS is only 36; for men

Chemists' starting salaries rise at all degree levels

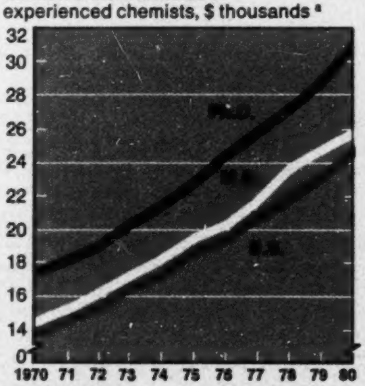
Median annual salaries of inexperienced chemists, $ thousands[a]



[a] Chemists with 12 months or less of professional experience; data as of about June of each year.
Source: ACS starting salary surveys

Salaries of experienced chemists continue to climb

Median annual salaries of experienced chemists, $ thousands[a]



[a] Chemists with more than 12 months of professional experience; data as of March of each year.
Source: ACS comprehensive salary surveys

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Salaries differ depending on type of work

Chemists earn reasonably good salaries. But how do they compare with those of other professionals?

Comparisons of this type are difficult to make because equivalent data are not available for many types of work. Some organizations, however, do collect salary information that is helpful in suggesting the level of earnings in various fields.

The American Medical Association, for example, estimates that the average net income (the average gross income less professional expenses) of physicians from their medical practice was $68,600 in 1979. The American Dental Association reports that the 1979 average net income of dentists from their professional practice was $48,363. According to the American Institute of Physics, the average salary of members of the organizations that comprise AIP (most of whom are physicists) was about $33,000 in May 1980.

Data on the salaries of workers in various white-collar occupations in private industry are compiled annually by the Department of Labor's Bureau of Labor Statistics. This information is collected mainly to determine whether the salaries the government pays its employees are in line with those of employees in industry. The data enable general comparisons to be made between the salaries earned in various professional and administrative occupations at differing levels of experience and job responsibility.

The latest BLS data on upper-level chemists are for people working at a somewhat lower level than was true last year (C&EN, Oct. 22, 1979, page 47). As a result, the salary reported for upper-level chemists last year ($48,961) was higher than for such chemists in 1980. The salary for upper-level chemists in 1979 equivalent to this year's figure was $42,016. A similar situation occurs with upper-level chief accountants and personnel directors.

	Average annual salary[a]
Attorneys, upper level	$60,641
Engineers, upper level	50,079
Chief accountants, upper level	50,073
Personnel directors, upper level	49,730
Chemists, upper level	45,883
Accountants, upper level	40,292
Engineers, middle level	28,486
Chief accountants, starting	28,347
Chemists, middle level	27,681
Personnel directors, starting	24,719
Attorneys, starting	20,911
Engineers, starting	19,411
Chemists, starting	16,200
Accountants, starting	15,149

[a] As of March 1980, excluding overtime and nonproduction bonuses, but including cost-of-living bonuses and incentive earnings. Source: Department of Labor's Bureau of Labor Statistics

it is 44. Because of their lower age, women members tend to have fewer years of professional experience. In addition, women chemists are less likely than men chemists to hold jobs that typically are high-paying, such as in management, and also are less likely to have a Ph.D. degree.

In private industry, the median salary of B.S. chemists in March 1980 was $26,800 for men and $19,800 for women. For M.S. chemists in private industry, the median was $29,100 for men and $23,100 for women. And for Ph.D. chemists in private industry, it was $36,000 for men and $28,800 for women.

The 1980 ACS starting salary survey, based on replies from close to 3300 inexperienced chemists and chemical engineers, shows that the median annual starting salary of inexperienced B.S. chemists working full time was $15,000, up from $14,500 reported in 1979. The 1979 figure, however, may have been unrepresentatively large. Starting salaries of B.S. chemists were found to have been up an unusual 14% by the 1979 survey, compared to this year's 3% increase and 1978's 6%.

The 1980 median starting salary of M.S. chemists rose to $20,000 from $17,000 in 1979. In the same period, the median starting salary of Ph.D. chemists climbed from $23,000 to $26,400.

As is typical, the median starting salaries of inexperienced chemical engineers exceed those of chemists. The median starting salary of B.S. chemical engineers working full time was $21,600 in 1980, compared to $19,800 in 1979, an increase of 9%. The median for M.S. chemical engineers increased 14% from $21,000 to $23,850. The median for Ph.D. chemical engineers climbed 13% from $25,400 to $28,800.

The type of employer has an effect on the median salaries of both chemists and chemical engineers. The medians for inexperienced full-time B.S. chemists were $16,800 in manufacturing industry; $14,750 in nonmanufacturing industry; $13,800 for those in federal, state, and local governments; $12,000 for those in hospitals, independent laboratories, and nonprofit organizations; and $10,300 for those in colleges and universities. The financial picture for academic chemists may not be so unfavorable as it may seem, however, since many supplement their incomes with summer jobs and consulting work.

The limited data available on the median starting salaries of full-time B.S. chemical engineers according to type of employer indicate that they received $21,900 if they work in manufacturing industry and $21,000 in nonmanufacturing industry.

In several recent years, median starting salaries of B.S. women chemists and chemical engineers in private industry have (contrary to what was true earlier) been higher than those of their male counterparts. This year, however, the median for B.S. women chemists was almost identical to that of men chemists—$16,750 vs. $16,800. On the other hand, the median for B.S. women chemical engineers was higher than that of men chemical engineers—$21,900 vs. $21,700. Starting salaries paid to women generally have been improving in recent years as employers attempt to increase the representation of women on their staffs.

Among inexperienced B.S. chemists in 1980, 36% were employed full time in the chemical profession. In addition, 42% had graduate assistantships or fellowships, 12% were working full time outside the chemical profession, 8% were unemployed but not seeking employment, and 2% were unemployed and seeking employment.

Among inexperienced Ph.D. chemists, 65% were working full time in the chemical profession, 33% had postdoctoral fellowships, and 2% were working full time outside the chemical profession.

Ph.D. chemists obviously are finding it much easier to get jobs today than they did several years ago. This is reflected in the fact that the proportion of inexperienced Ph.D. chemists working full time in the chemical profession has increased from 44% in 1976 to 56% in 1979 and to 65% in 1980. Furthermore, the percentage of new Ph.D.'s who do postdoctoral work (sometimes because they are unable to obtain other employment) has fallen from a high of 49% in 1976 to 38% in 1979 and 33% this year.

Most inexperienced chemical engineers in 1980 had jobs in the chemical profession—78% of B.S.'s, 86% of M.S.'s, and nearly all of Ph.D.'s. A few were employed outside the chemical profession—9% of the B.S.'s and 2% of the M.S.'s. Some had assistantships or fellowships—11% of the B.S.'s and 8% of the M.S.'s. Nearly none of the chemical engineers were unemployed. □

CAREER 1981 PLANNING

Career Planning is designed to acquaint both the student and the experienced graduate with services, sources of information, and organizations that can supply guidance in selecting, obtaining, and changing careers. The directory is a guide to U.S. organizations that employ significant numbers of chemists and chemical engineers. It is, of course, not all-inclusive. The directories listed under General Information, for instance, include the names of other organizations that employ chemists and chemical engineers. Inquiries about career opportunities in specific organizations should be addressed directly to the organization, in care of the personnel director.

GENERAL INFORMATION

American Chemical Society: *Chemical & Engineering News* salary surveys, employment surveys, and classified ads (see also ACS Information below), 1155—16th St., N.W., Washington, D.C. 20036.

Directories: "American Council of Independent Laboratories Directory, 1980," 1725 K St., N.W., Washington, D.C. 20006; "Association of Consulting Chemists & Chemical Engineers Council Directory," 20th edition, 1980, 50 East 41st St., New York, N.Y. 10017; "College Placement Annual, 1981," College Placement Council, P.O. Box 2263, Bethlehem, Pa. 18801; "American Consulting Engineers Council Membership Directory, 1980–81," 1155—15th St., N.W., Washington, D.C. 20005; "Directory of Chemical Producers, 1980," SRI International, Menlo Park, Calif. 94025; "Industrial Research Laboratories of the United States," 16th edition, 1979 (1981 edition will be available in the fall of 1981), R. R. Bowker Co., 1180 Ave. of the Americas, New York, N.Y. 10036; "Research Centers Directory," 6th edition, 1979 (7th edition will be available in July 1981), Gale Research Co., Book Tower, Detroit, Mich. 48226.

Scientific Manpower Commission: "Science and Engineering Careers—A Bibliography," April 1974, $2.00; "Salaries of Scientists, Engineers, and Technicians," 9th edition, November 1979, $20; "Professional Women and Minorities—A Manpower Data Resource Service," 2nd edition, November 1978, $75 (1980 supplement, $30); "Supply and Demand for Scientists and Engineers—A Review of Selected Studies," February 1977, $3.00; "Manpower Planning for Scientists and Engineers," May 1977, $2.00; *Manpower Comments*, 10 issues a year, $25 per year. All available from 1776 Massachusetts Ave., N.W., Washington, D.C. 20036.

Scientific and professional societies: American Institute of Chemists, 7315 Wisconsin Ave., N.W., Washington, D.C. 20014; American Institute of Chemical Engineers, 345 East 47th St., New York, N.Y. 10017; and National Society of Professional Engineers, 2029 K St., N.W., Washington, D.C. 20006. They offer information on their specific programs for career guidance.

Sources of information about prospective employers: Available in many public libraries, "Moody's Industrial Manual," "Dun & Bradstreet," "Thomas Register of American Manufacturers," and "Standard and Poor's Register."

U.S. Department of Labor: Occupational Outlook Handbook, 1980–81 edition, Bulletin 2075, $11 per hardback copy and $8.00 per paperback copy. Order from Bureau of Labor Statistics, 1515 Broadway, New York, N.Y. 10036, or other office of BLS.

Vocational guidance manuals: "Opportunities in Chemistry" by John H. Woodburn, 1978; "Opportunities in Environmental Careers" by Odom Fanning, 1975; "Opportunities in Materials Science and Engineering" by Charles Wert, 1979; "Opportunities in Energy Careers" by John H. Woodburn, 1978; and "Opportunities in Chemical Engineering" by D. Joseph Hagerty, Earl R. Gerhard, and Charles A. Plank, 1978. Available from VGM Career Horizons, a division of National Textbook Co., 8259 Niles Center Rd., Skokie, Ill. 60077. "Encyclopedia of Careers and Vocational Guidance" by William E. Hokpe, editor, 1978. Volume 1: "Planning Your Career." Volume 2: "Careers and Occupations." "Woman's Guide to Career Preparation" by Ann Jawin, 1979. Available from Doubleday & Co., 501 Franklin Ave., Garden City, N.Y. 11530. "Peterson's Annual Guide to Careers and Employment for Engineers, Computer Scientists, and Physical Scientists," 1980 edition. Available from Peterson's Guides, P.O. Box 2123, Princeton, N.J. 08540.

ACS INFORMATION

Education aids for high school students: "Careers in Chemistry: Questions and Answers," "List of ACS Approved Schools," and "Financial Aids for College Students." All single copies free from ACS Special Issues Sales. *SciQuest,* published 10 times a year, $10 per year ($12 in 1981) or $25 for three years ($29 in 1981). Student group rates of 10 or more subscriptions entered with a single payment but mailed to different addresses, $6.50 each (also in 1981). Bulk subscriptions that are entered with a single payment for the school term and are mailed to one address, as low as $3.75 each, depending on the number of subscriptions ordered. Available from ACS Circulation Development Department, 1155—16th St., N.W., Washington, D.C. 20036.

Education aids for college students: "College Chemistry Seniors," a listing of résumés submitted by seniors majoring in chemistry and chemical engineering who plan to enter graduate school, 1980–81 edition, $50; "Directory of Graduate Research," a listing of Ph.D. degree-granting departments of chemistry, chemical engineering, biochemistry, and pharmaceutical/medicinal chemistry in the U.S. and Canada, with names of faculties, their research interests, and bibliographies of their recent publications, 1979 edition, $30; and "College Chemistry Faculties," a listing of two- and four-year college and university teachers of chemistry, chemical engineering, and biochemistry in the U.S., Canada, and Mexico, 5th edition (1980), $25. All available from ACS Special Issues Sales. "Graduate School Information Aids," "Careers Nontraditional," and "Chemical Careers in the 1980's," are also available from ACS Special Issues Sales, single copy free. *Journal of Chemical Education,* a monthly publication of the ACS Division of Chemical Education, $15 per year for regular domestic subscribers and $11.25 per year for students. Available from *Journal of Chemical Education,* Subscription Fulfillment Department, 20th & Northampton St., Easton, Pa. 18042.

Continuing education aids: ACS Short Courses, live, intensive state-of-the-art courses in chemistry offered publicly year round, also available to organizations on an in-house basis; ACS Audio Courses, taped state-of-the-art courses by recognized authorities; ACS Film/Video Courses, chemistry lectures on 16-mm film and videotape; and ACS Interaction Courses, correspondence courses developed by experts and given by well-qualified instructors. All available from ACS Department of Educational Activities.

Employment information: ACS publishes several annual volumes of statistical data about the chemical profession and the salaries paid to its members: "Salaries 1980," the results of a salary survey of the ACS membership, 75 pages, $25; "Professionals in Chemistry 1978," a statistical yearbook, 74 pages, $25; and "Starting Salaries 1979," the results of a survey of new graduates in chemistry and chemical engineering, 61 pages, $5.00 (the 1980 edition will be available in early November for $10). All from ACS Special Issues Sales. The 1978 edition of "Professional Employment Guidelines" is free; send stamped, self-addressed, business-size envelope; "Chemistry: A Job or a Career?" consists of a 30-minute cassette tape, booklets, and a slide presentation that are offered free to student affiliate chapters and to chemistry and chemical engineering departments. Available from ACS Department of Professional Relations & Manpower Studies.

Salary information in C&EN: Starting salaries in 1979, C&EN, Oct. 22, 1979, page 46. Comprehensive salary survey in 1980, C&EN, June 30, page 25.

ACS EMPLOYMENT AIDS

Employment Clearing House: ACS members and student affiliates in search of a new position can file applications in the Washington office at no charge. Employers may write or call the Washington office to receive copies of résumés of applicants who possess qualifications specified for the positions. The service is year-round and nonconfidential.

Confidential Employment Listing: This service enables employed ACS members who are seeking a new position to have their records on file at the ACS Employment Aids Office and to have them made available to all but certain specified employers, such as their present employer. This listing enables experienced candidates who otherwise would not wish to have their records circulated on a nonrestricted basis to let all but specified employers know of their desire to find a new position. Because of the added cost of handling such confidential records, ACS members are charged $25 a year for such a listing.

Employment Clearing House, National Meetings: The society aids ACS members and employers to arrange on-the-spot interviews at ACS national meetings. This free, nonconfidential service is open to those registered and in attendance at the meeting. Unemployed members may have registration fees waived on request.

Academic Openings: This publication lists positions, including postdoctoral positions, available at colleges and universities. It is published on a monthly basis if sufficient notices are received from academic institutions. The 20th of any month is the deadline for publication. If too few listings are received, publication is held over until the next month. This service is provided for all those interested in academic employment. Subscriptions to Academic Openings are $12 a year and can be obtained by writing to the ACS Employment Aids Office.

C&EN employment advertising section: Student affiliates and employed ACS members receive discounts from regular advertising rates. ACS members who are unemployed or are under notice of involuntary unemployment within 60 days may place one free classified "situations wanted" advertisement that will appear in every other issue for a period of six months—for a total of 13 insertions a year. Student members or student affiliates who have not gained employment two months before graduation are entitled to the same privileges. Retired members are entitled to six free nondisplay advertisements a year. See the Employment Ads Information box at the start of the C&EN employment advertising section for instructions.

Résumé service: An unemployed member may obtain free up to 50 printed copies of his or her résumé, limited to two pages typed in reproducible form. Write ACS Employment Aids Office.

ACS local sections: Some sections provide job assistance. Contact the secretary of local section.

For ACS information listed in this section, write to American Chemical Society, 1155—16th St., N.W., Washington, D.C. 20036.

OTHER EMPLOYMENT SERVICES

Classified listings: *Chemical & Engineering News*, weekly newsmagazine of the American Chemical Society; *Chemical Engineering Progress*, monthly magazine of the American Institute of Chemical Engineers; *The Chemist*, monthly publication of the American Institute of Chemists; *Science*, weekly magazine of the American Association for the Advancement of Science; and classified sections of newspapers.

College placement bureaus: Campus placement offices usually maintain a file of openings for graduating students and recent graduates. They frequently arrange interviews between students and employers.

Private placement agencies: Check those in your area to determine what services are offered. They differ in quality, cost, and nature of service.

State employment agencies: These organizations list openings for professional people without charge and also provide guidance on available government programs for retraining scientists and engineers.

U.S. Civil Service Commission: This agency maintains a listing of open examinations for jobs in government laboratories and other installations. Descriptions, locations, and salary information are available by writing to the commission at 1900 E St., N.W., Washington, D.C. 20415.

ORGANIZATIONS FOR WOMEN

American Association for the Advancement of Science: Office of Opportunities in Science, 1776 Massachusetts Ave., N.W., Washington, D.C. 20036; Women's Caucus, Yolanda Scott George, Professional Development Program, University of California, Berkeley, Berkeley, Calif. 94720.

American Association of University Professors: Committee on Status of Women in the Profession, AAUP, 1 Dupont Circle, N.W., Washington, D.C. 20036.

American Chemical Society: Women Chemists Committee, Wanda L. Brown, 212 Brightwood Pl., San Antonio, Tex. 78209.

American Society of Biological Chemists: Committee on Equal Opportunities for Women, Elizabeth S. Maxwell, ASBC, 9650 Rockville Pike, Bethesda, Md. 20014.

Association for Women in Science: Room 1122, 1346 Connecticut Ave., N.W., Washington, D.C. 20036.

Sigma Delta Epsilon—Graduate Women in Science: c/o Federation of American Societies for Experimental Biology, 9650 Rockville Pike, Bethesda, Md. 20014.

Iota Sigma Pi—National Honor Society for Women in Chemistry: Anne T. Sherren, Department of Chemistry, North Central College, Naperville, Ill. 60540.

Society of Women Engineers: Mary Lou Barnas, Executive Secretary, Room 305, 345 East 47th St., New York, N.Y. 10017.

Directory

The following list includes most of the nation's major employers of chemists and/or chemical engineers. The organizations did not ask to be included in this directory and are not necessarily hiring chemists or chemical engineers at this time.

Chemicals

Aceto Chemical Co., 126-02 Northern Blvd., Flushing, N.Y. 11368
Airco, 85 Chestnut Ridge Rd., Montvale, N.J. 07645 (subsidiary of BOC International Ltd. of the U.K.)
Air Products & Chemicals, P.O. Box 538, Allentown, Pa. 18105
Akzona, P.O. Box 2930, Asheville, N.C. 28802 (affiliated with Akzo N.V. of the Netherlands)
Alcolac, 3440 Fairfield Rd., Baltimore, Md. 21226
Aldrich Chemical Co., 940 West St. Paul Ave., Milwaukee, Wis. 53233
Allied Chemical Corp., P.O. Box 2245R, Morristown, N.J. 07960
American Color & Chemical Corp., P.O. Box 32516, Charlotte, N.C. 28232 (subsidiary of North American Philips Corp. and Koppers Co.)
American Cyanamid Co., Berdan Ave., Wayne, N.J. 07470
American Enka Co., Enka, N.C. 28728 (division of Akzona)
American Hoechst Corp., Rte. 202-206 North, Somerville, N.J. 08876 (owned by Hoechst A.G. of West Germany)
American Hoechst Corp., industrial chemicals division, P.O. Box 268, Coventry, R.I. 02816
Amoco Chemicals Corp., 200 East Randolph Dr., Chicago, Ill. 60601 [subsidiary of Standard Oil Co. (Ind.)]
Ansul Co., 1 Stanton St., Marinette, Wis. 54143
Apex Chemical Co., 200 South First St., Elizabethport, N.J. 07206
Arco Chemical Co., 1500 Market St., Philadelphia, Pa. 19101 (division of Atlantic Richfield Co.)
Arizona Chemical Co., Berdan Ave., Wayne, N.J. 07470 (affiliate of American Cyanamid Co. and International Paper Co.)
Armak Co., P.O. Box 1805, Chicago, Ill. 60690 (subsidiary of Akzona)
Ashland Chemical Co., P.O. Box 2219, Columbus, Ohio 43216 (division of Ashland Oil)
AZS Corp., P.O. Box 93366, Atlanta, Ga. 30318
Badische Corp., Williamsburg, Va. 23185 (member of BASF Group of West Germany)
J. T. Baker Chemical Co., 600 North Broad St., Phillipsburg, N.J. 08865 (subsidiary of Richardson-Merrell)
BASF Wyandotte Corp., 100 Cherry Hill Rd., Parsippany, N.J. 07054 (owned by BASF A.G. of West Germany)
Beaunit Corp., 261 Madison Ave., New York, N.Y. 10016 (subsidiary of El Paso Natural Gas Co.)
Betz Laboratories, 4636 Somerton Rd., Trevose, Pa. 19047
Big Three Industries, P.O. Box 3047, Houston, Tex. 77001
Borden Chemical, 180 East Broad St., Columbus, Ohio 43215 (division of Borden)
Borg-Warner Corp., 200 South Michigan Ave., Chicago, Ill. 60604
Buckeye Cellulose Corp., P.O. Box 8407, Memphis, Tenn. 38108 (subsidiary of Procter & Gamble Co.)
Buckman Laboratories, 1256 North McLean Blvd., Memphis, Tenn. 38108
Cabot Corp., 125 High St., Boston, Mass. 02110
Calbiochem-Behring Corp., 10933 North Torrey Pines Rd., La Jolla, Calif. 92037 (subsidiary of American Hoechst Corp.)
Calgon Corp., P.O. Box 1346, Pittsburgh, Pa. 15230 (subsidiary of Merck & Co.)
Callery Chemical Co., Callery, Pa. 16024 (division of Mine Safety Appliances Co.)
Carus Corp., 1500 Eighth St., La Salle, Ill. 61301
Celanese Corp., 1211 Ave. of the Americas, New York, N.Y. 10036
CF Industries, Salem Lake Dr., Long Grove, Ill. 60047
Chemed Corp., 1200 DuBois Tower, Cincinnati, Ohio 45202 (owned 90% by W. R. Grace & Co.)
Chemetron Corp., 111 East Wacker Dr., Chicago, Ill. 60601 (subsidiary of Allegheny Ludlum Industries)
Chemplex Co., 3100 Gold Rd., Rolling Meadows, Ill. 60008 (jointly owned by American Can Co. and Getty Oil Co.)
Chevron Chemical Co., 575 Market St., San Francisco, Calif. 94105 (subsidiary of Standard Oil Co. of California)
Ciba-Geigy Corp., 444 Saw Mill River Rd., Ardsley, N.Y. 10502 (owned by Ciba-Geigy Ltd. of Switzerland)
Cincinnati Milacron, 4701 Marburg Ave., Cincinnati, Ohio 45209
City Chemical Corp., 132 West 22nd St., New York, N.Y. 10011
Clorox Co., 1221 Broadway, Oakland, Calif. 94612 (owned 15% by Henkel KGaA of West Germany)
Columbia Nitrogen Corp., P.O. Box 1483, Augusta, Ga. 30903 (owned by DSM of the Netherlands)
Conoco Chemicals Co., P.O. Box 2197, Houston, Tex. 77001 (division of Conoco)
Cooperative Farm Chemicals Association, P.O. Box 308, Lawrence, Kan. 66044 (owned by Farmland Industries and Missouri Farmers Association)
Copolymer Rubber & Chemical Corp., P.O. Box 2591, Baton Rouge, La. 70821
Cordova Chemical of Michigan, 500 Agard Rd., Muskegon, Mich. 49445
Crompton & Knowles Corp., chemicals group, Rte. 208, Fair Lawn, N.J. 07410
Cyclo Chemicals Corp., 7500 North West 66th St., Miami, Fla. 33166
Dart Industries, P.O. Box 3157, Terminal Annex, Los Angeles, Calif. 90051
Daubert Chemical Co., 1200 Jorie Blvd., Oak Brook, Ill. 60521
Dearborn Chemical, 300 Genesee St., Lake Zurich, Ill. 60047 (division of Chemed Corp.)
Detrex Chemical Industries, 4000 Town Ctr., Southfield, Mich. 48075
Dexter Chemical Corp., 845 Edgewater Rd., Bronx, N.Y. 10474
Dexter Corp., 1 Elm St., Windsor Locks, Conn. 06096
Diamond Shamrock Corp., 2300 Southland Ctr., Dallas, Tex. 75201
Diversey Corp., 100 West Monroe St., Chicago, Ill. 60603
Dixie Chemical Co., P.O. Box 13410, Houston, Tex. 77019
Dow Chemical U.S.A., 2020 Dow Ctr., Midland, Mich. 48640
Dow Corning Corp., P.O. Box 1767, Midland, Mich. 48640 (jointly owned by Dow Chemical Co. and Corning Glass Works)
Drew Chemical Corp., 1 Drew Chemical Plaza, Boonton, N.J. 07005 (subsidiary of U.S. Filter Corp.)
DuBois Chemicals, 1314 DuBois Tower, Cincinnati, Ohio 45202 (division of Chemed Corp.)
E. I. du Pont de Nemours & Co., 1007 Market St., Wilmington, Del. 19898
Eagle-Picher Industries, 580 Walnut St., Cincinnati, Ohio 45202
Eastern Chemical division, P.O. Box 2500, Hauppauge, N.Y. 11787 (division of Guardian Chemical Corp.)
Eastman Chemical Products, P.O. Box 431, Kingsport, Tenn. 37662 (subsidiary of Eastman Kodak Co.)
Economics Laboratory, 370 Wabasha St., St. Paul, Minn. 55102
Emery Industries, 1300 Carew Tower, Cincinnati, Ohio 45202 (subsidiary of National Distillers & Chemical Corp.)
Emkay Chemical Co., 319–325 Second St., Elizabeth, N.J. 07206
Enserch Corp., 301 South Harwood St., Dallas, Tex. 75201
Essex Chemical Corp., 1401 Broad St., Clifton, N.J. 07015
Ethyl Corp., 330 South Fourth St., Richmond, Va. 23219
Exxon Chemical Co., 1251 Ave. of the Americas, New York, N.Y. 10020 (division of Exxon Corp.)
Fairmount Chemical Co., 117 Blanchard St., Newark, N.J. 07105
Farmland Industries, P.O. Box 7305, Kansas City, Mo. 64116
Ferro Corp., 1 Erieview Plaza, Cleveland, Ohio 44114
Fiber Industries, P.O. Box 32414, Charlotte, N.C. 28232 (jointly owned by Celanese Corp. and Imperial Chemical Industries of the U.K.)
Filtrol Corp., 5959 West Century Blvd., Los Angeles, Calif. 90045 (subsidiary of U.S. Filter Corp.)
Firestone Plastics Co., P.O. Box 699, Pottstown. Pa. 19464 (division of Firestone Tire & Rubber Co.)
First Chemical Corp., P.O. Box 1427, Pascagoula, Miss. 39567 (subsidiary of First Mississippi Corp.)
Fisher Scientific Co., chemical manufacturing division, 711 Forbes Ave., Pittsburgh, Pa. 15219
FMC Corp., 200 East Randolph Dr., Chicago, Ill. 60601
FMC Corp., industrial chemical group, 2000 Market St., Philadelphia, Pa. 19103
Foster Grant Products Corp., 289 North Main St., Leominster, Mass. 01453 (subsidiary of American Hoechst Corp.)
Fritzsche Dodge & Olcott, 76 Ninth Ave., New York, N.Y. 10011
GAF Corp., 140 West 51st St., New York, N.Y. 10020
General Electric Co., engineered materials group, 500 West Wilson Bridge Rd., Columbus, Ohio 43285
General Electric Co., plastics business division, 1 Plastics Ave., Pittsfield, Mass. 01201
General Latex & Chemical Corp., 666 Main St., Cambridge, Mass. 02139
General Tire & Rubber Co., chemical/plastics division, 1 General St., Akron, Ohio 44329
Georgia-Pacific Corp., 900 South West Fifth Ave., Portland, Ore. 97204
Givaudan Corp., 100 Delawanna Ave., Clifton, N.J. 07014
Glyco Chemicals, P.O. Box 700, Greenwich, Conn. 06830
B. F. Goodrich Co., chemical group, 6100 Oak Tree Blvd., Cleveland, Ohio 44131
Goodyear Tire & Rubber Co., chemical division, 1144 East Market St., Akron, Ohio 44316
W. R. Grace & Co., 1114 Ave. of the Americas, New York, N.Y. 10036 (owned 28% by Flick Group of West Germany)
Great Lakes Carbon Corp., 299 Park Ave., New York, N.Y. 10017
Great Lakes Chemical Corp., P.O. Box 2200, West Lafayette, Ind. 47906
Great Salt Lake Minerals & Chemicals Corp., P.O. Box 1190, Ogden, Utah 84402 (subsidiary of Gulf Resources & Chemical Corp.)
Grow Group, 200 Park Ave., New York, N.Y. 10017
GTE Sylvania, 1 Stamford Forum, Stamford, Conn. 06904 (subsidiary of General Telephone & Electronics Corp.)
Guardian Chemical Corp., 230 Marcus Blvd., Hauppauge, N.Y. 11787
Gulf Oil Chemicals Co., P.O. Box 3766, Houston, Tex. 77001 (division of Gulf Oil Corp.)
Hach Chemical Co., P.O. Box 389, Loveland, Colo. 80537
C. P. Hall Co., 7300 South Central Ave., Chicago, Ill. 60638
Harshaw Chemical Co., 1945 East 97th St., Cleveland, Ohio 44106 (subsidiary of Gulf Oil Corp.)
Henkel Corp., 4620 West 77th St., Minneapolis, Minn. 55435 (owned by Henkel KGaA of West Germany)
Hercules, 910 Market St., Wilmington, Del. 19899
Hilton-Davis Chemical Co., 2235 Langdon Farm Rd., Cincinnati, Ohio 45237 (division of Sterling Drug)
Hitco, 1600 West 135th St., Gardena, Calif. 90249 (subsidiary of Armco)
Hoechst Fibers Industries, 1515 Broadway, New York, N.Y. 10036 (division of American Hoechst Corp.)
Hooker Chemical Co., P.O. Box 4289, Houston, Tex. 77210 (subsidiary of Occidental Petroleum Corp.)
Humko Sheffield Chemical, P.O. Box 398, Memphis, Tenn. 38101 (division of Kraft)
Humphrey Chemical Co., Devine St., North Haven, Conn. 06473
Philip A. Hunt Chemical Corp., P.O. Box 800, Palisades Park, N.J. 07650 (partly owned by Turner & Newall Ltd. of the U.K.)
ICI Americas, Concord Pike & New Murphy Rd., Wilmington, Del. 19897 (owned by Imperial Chemical Industries Ltd. of the U.K.)
IMC Chemical Group, 666 Garland Pl., Des Plaines, Ill. 60016 (subsidiary of International Minerals & Chemical Corp.)
Inmont Corp., 1133 Ave. of the Americas, New York, N.Y. 10036 (subsidiary of Carrier Corp.)

Directory

International Flavors & Fragrances, 521 West 57th St., New York, N.Y. 10019
International Minerals & Chemical Corp., 2315 Sanders Rd., Northbrook, Ill. 60062
Jefferson Chemical Co., P.O. Box 430, Bellaire, Tex. 77401 (subsidiary of Texaco)
Kaiser Chemicals, 300 Lakeside Dr., Oakland, Calif. 94643 (division of Kaiser Aluminum & Chemical Corp.)
Kay-Fries, Stony Point, N.Y. 10980 (owned 75% by Dynamit Nobel A.G. of West Germany and 25% by Tennants Consolidated Ltd. of the U.K.)
Kerr-McGee Chemical Corp., Kerr-McGee Ctr., Oklahoma City, Okla. 73125 (subsidiary of Kerr-McGee Corp.)
Koppers Co., Koppers Bldg., Pittsburgh, Pa. 15219
Lawter Chemicals, 990 Skokie Blvd., Northbrook, Ill. 60062
Liquid Air Corp. of North America, 405 Lexington Ave., New York, N.Y. 10017
Liquid Carbonic Corp., 135 South La Salle St., Chicago, Ill. 60603 (subsidiary of Houston Natural Gas Corp.)
Lithium Corp. of America, 449 North Cox Rd., Gastonia, N.C. 28052 (subsidiary of Gulf Resources & Chemical Corp.)
Lonza, 22-10 Rte. 208, Fair Lawn, N.J. 07410 (owned by Lonza A.G. of Switzerland)
Lubrizol Corp., 29400 Lakeland Blvd., Wickliffe, Ohio 44092
MacKenzie Chemical Works, 1 Cordello Ave., Central Islip, N.Y. 11722
MacKenzie Chemical Works of Louisiana, P.O. Box 219, Bush, La. 70431
Mallinckrodt, P.O. Box 5840, St. Louis, Mo. 63134
MCB Reagents, 2909 Highland Ave., Norwood, Ohio 45212 (associate of E. Merck of West Germany)
Millmaster Onyx Group, 99 Park Ave., New York, N.Y. 10016 (subsidiary of Gulf Oil Corp.)
Mobay Chemical Corp., Penn Lincoln Pkwy. West, Pittsburgh, Pa. 15205 (owned by Bayer A.G. of West Germany)
Mobil Chemical Co., 150 East 42nd St., New York, N.Y. 10017 (division of Mobil Oil Corp.)
Monsanto Co., 800 North Lindbergh Blvd., St. Louis, Mo. 63166
Morton Chemical Division, 2 North Riverside Plaza, Chicago, Ill. 60606 (division of Morton-Norwich Products)
M&T Chemicals, Woodbridge Rd. & Randolph Ave., Rahway, N.J. 07065 (subsidiary of Société Nationale Elf-Aquitaine of France)
Nalco Chemical Co., 2901 Butterfield Rd., Oak Brook, Ill. 60521
National Distillers & Chemical Corp., 99 Park Ave., New York, N.Y. 10016
National Starch & Chemical Corp., 10 Finderne Ave., Bridgewater, N.J. 08807 (owned by Unilever of the U.K.)
Neville Chemical Co., 1938 Neville Island, Pittsburgh, Pa. 15225
New England Nuclear Corp., 549 Albany St., Boston, Mass. 02118
NL Chemicals, P.O. Box 700, Hightstown, N.J. 08520 (division of NL Industries)
Northern Petrochemical Co., 2223 Dodge St., Omaha, Neb. (subsidiary of Northern Natural Gas Co.)
Norton Chemical Process Products division, P.O. Box 350, Akron, Ohio 44309 (division of Norton Co.)
Noury Chemical Corp., Rte. 78, Burt, N.Y. 14028 (subsidiary of Armak Co.)
Olin Corp., 120 Long Ridge Rd., Stamford, Conn. 06904
Oxirane International, 4550 Post Oak Place Dr., Houston, Tex. 77027 (jointly owned by Atlantic Richfield Co. and Halcon International)
Ozark-Mahoning Co., 1870 South Boulder Ave., Tulsa, Okla. 74119 (subsidiary of Pennwalt Corp.)
Pacific Resins & Chemicals, 1754 Thorne Rd., Tacoma, Wash. 98421 (subsidiary of Univar Corp.)
Pantasote, 26 Jefferson St., Passaic, N.J. 07055
Pearsall Chemical Corp., P.O. Box 437, Houston, Tex. 77001
Penick Corp., 1050 Wall St. West, Lyndhurst, N.J. 07071 (unit of CPC International)
Pennwalt Corp., 3 Pkwy., Philadelphia, Pa. 19102
Petro-Tex Chemical Corp., 8600 Park Place Blvd., Houston, Tex. 77017 (subsidiary of Tenneco Oil Co.)
Pfanstiehl Laboratories, 1219 Glen Rock Ave., Waukegan, Ill. 60085
Pfister Chemical, Linden Ave., Ridgefield, N.J. 07657
Phillips Fibers Corp., P.O. Box 66, Greenville, S.C. 29602 (subsidiary of Phillips Petroleum Co.)
Pierce Chemical Co., P.O. Box 117, Rockford, Ill. 61105
PPG Industries, 1 Gateway Ctr., Pittsburgh, Pa. 15222
PQ Corp., P.O. Box 840, Valley Forge, Pa. 19482
Publicker Industries, 777 West Putnam Ave., Greenwich, Conn. 06830
PVO International, World Trade Ctr., San Francisco, Calif. 94111
Quaker Oats Co., chemicals division, P.O. Box 3514, Chicago, Ill. 60654
Reichhold Chemicals, 523 North Broadway, White Plains, N.Y. 10603
Reilly Tar & Chemical Corp., 151 North Delaware St., Indianapolis, Ind. 46204
Rexene Co., P.O. Box 665, Paramus, N.J. 07652 (division of El Paso Polyolefins Co.)
Rhône-Poulenc, 600 Madison Ave., New York, N.Y. 10022 (subsidiary of Rhône-Poulenc S.A. of France)
Richardson Co., 2400 East Devon Ave., Des Plaines, Ill. 60018
Rilsan Corp., 139 Harristown Rd., Glen Rock, N.J. 07452 (owned by ATO Chimie S.A. of France)
Ritter International, 4001 Goodwin Ave., Los Angeles, Calif. 90039
Rohm & Haas Co., Independence Mall West, Philadelphia, Pa. 19105
R.S.A. Corp., 690 Saw Mill River Rd., Ardsley, N.Y. 10502
Rubicon Chemicals, P.O. Box 517, Geismar, La. 70734 (jointly owned by Imperial Chemical Industries of the U.K. and by Uniroyal)
Sandoz, Rte. 10, East Hanover, N.J. 07936 (owned by Sandoz A.G. of Switzerland)
SCM Corp., 299 Park Ave., New York, N.Y. 10017
Shell Chemical Co., P.O. Box 2463, Houston, Tex. 77001 (division of Shell Oil Co.)
Shepherd Chemical Co., 4900 Beech St., Cincinnati, Ohio 45212
Stauffer Chemical Co., Nyala Farm Rd., Westport, Conn. 06880
Stepan Chemical Co., Edens & Winnetka Rd., Northfield, Ill. 60093
Sterling Organics, 90 Park Ave., New York, N.Y. 10016 (division of Sterling Drug)
Sun Chemical Corp., 200 Park Ave., New York, N.Y. 10017
Sybron Corp., 1100 Midtown Tower, Rochester, N.Y. 14604
Tenneco Chemicals, Park 80 Plaza West, Saddle Brook, N.J. 07662 (division of Tenneco)
Thompson-Hayward Chemical Co., 5200 Speaker Rd., Kansas City, Kan. 66110 (subsidiary of North American Philips Corp.)
Toms River Chemical Corp., P.O. Box 71, Toms River, N.J. 08753 (jointly owned by Ciba-Geigy Corp. and Sandoz A.G. of Switzerland)
Union Carbide Corp., 270 Park Ave., New York, N.Y. 10017
Union Chemicals division, 1345 North Meacham Rd., Schaumburg, Ill. 60196 (division of Union Oil Co. of California)
Uniroyal Chemical, Spencer St., Naugatuck, Conn. 06770 (division of Uniroyal)
United Nuclear Corp., 7700 Leesburg Pike, Falls Church, Va. 22043 (subsidiary of UNC Resources)
U.S. Borax & Chemical Corp., 3075 Wilshire Blvd., Los Angeles, Calif. 90010 (owned by Rio Tinto Zinc Corp. of the U.K.)
U.S. Industrial Chemicals Co., 99 Park Ave., New York, N.Y. 10016 (division of National Distillers & Chemical Corp.)
USM Corp., 426 Colt Hwy., Farmington, Conn. 06032 (subsidiary of Emhart Corp.)
USS Chemicals, 600 Grant St., Pittsburgh, Pa. 15230 (division of U.S. Steel Corp.)
USS Novamont, 600 Grant St., Pittsburgh, Pa. 15230 (subsidiary of U.S. Steel Corp.)
Vanderbilt Chemical Corp., 30 Winfield St., Norwalk, Conn. 06855 (subsidiary of R. T. Vanderbilt Co.)
Velsicol Chemical Corp., 341 East Ohio St., Chicago, Ill. 60611 (subsidiary of Northwest Industries)
Ventron Corp., Congress St., Beverly, Mass. 01915 (division of Thiokol Corp.)
Virginia Chemicals, 3340 West Norfolk Rd., Portsmouth, Va. 23703
Vistron Corp., Midland Bldg., Cleveland, Ohio 44115 [subsidiary of Standard Oil Co. (Ohio)]
Vulcan Materials Co., P.O. Box 7497, Birmingham, Ala. 35223
West Agro Chemical, P.O. Box 1386, Shawnee Mission, Kan. 66222 (subsidiary of West Chemical Products)
West Chemical Products, 8 Freer St., Lynbrook, N.Y. 11563
Williams Cos., 1 Williams Ctr., Tulsa, Okla. 74103
Witco Chemical Corp., 277 Park Ave., New York, N.Y. 10017

Drugs

Abbott Laboratories, 1400 Sheridan Rd., North Chicago, Ill. 60064
American Home Products Corp., 685 Third Ave., New York, N.Y. 10017
Ames division, P.O. Box 70, Elkhart, Ind. 46515 (division of Miles Laboratories)
Armour Pharmaceutical Co., P.O. Box 1849, Scottsdale, Ariz. 85251 (subsidiary of Revlon)
Ayerst Laboratories, 685 Third Ave., New York, N.Y. 10017 (division of American Home Products Corp.)
Baxter Travenol Laboratories, 1 Baxter Pkwy., Deerfield, Ill. 60015
Breon Laboratories, 90 Park Ave., New York, N.Y. 10016 (subsidiary of Sterling Drug)
Bristol Laboratories, P.O. Box 657, Syracuse, N.Y. 13201 (division of Bristol-Myers Co.)
Bristol-Myers Co., 345 Park Ave., New York, N.Y. 10022
Burroughs Wellcome Co., 3030 Cornwallis Rd., Research Triangle Park, N.C. 27709 (owned by Wellcome Foundation Ltd. of the U.K.)
Carter-Wallace, 767 Fifth Ave., New York, N.Y. 10022
Ciba-Geigy Corp., pharmaceuticals division, 556 Morris Ave., Summit, N.J. 07901 (owned by Ciba-Geigy A.G. of Switzerland)
Cooper Laboratories, 5 Palo Alto Sq., Palo Alto, Calif. 94304
Cutter Laboratories, Fourth & Parker St., Berkeley, Calif. 94710 (owned by Bayer A.G. of West Germany)
Dorsey Laboratories, P.O. Box 83288, Lincoln, Neb. 68501 (division of Sandoz of Switzerland)
Endo Laboratories, 1000 Stewart Ave., Garden City, N.Y. 11530 (subsidiary of Du Pont)
Ethicon, U.S. Hwy. 22, Somerville, N.J. 08876 (subsidiary of Johnson & Johnson)
Ganes Chemicals, 1114 Ave. of the Americas, New York, N.Y. 10036 (owned by Siegfried A.G. of Switzerland)
Hoechst-Roussel Pharmaceuticals, Rte. 202-206 North, Somerville, N.J. 08876 (subsidiary of American Hoechst)
Hoffmann-La Roche, 340 Kingsland St., Nutley, N.J. 07110 (member of Hoffmann-La Roche Group of Switzerland)
ICN Pharmaceuticals, 2727 Campus Dr., Irvine, Calif. 92664
Inolex Pharmaceutical, 2600 Bond St., Park Forest South, Ill. 60466 (division of Inolex Corp.)
Lederle Laboratories, North Middletown Rd., Pearl River, N.Y. 10965 (division of American Cyanamid Co.)
Eli Lilly & Co., 740 South Alabama St., Indianapolis, Ind. 46206
Marion Laboratories, 10236 Bunker Ridge Rd., Kansas City, Mo. 64137
McNeil Laboratories, 500 Office Center Dr., Fort Washington, Pa. 19034 (affiliate of Johnson & Johnson)
Mead Johnson & Co., 2404 Pennsylvania St., Evansville, Ind. 47721 (subsidiary of Bristol-Myers Co.)
Merck & Co., P.O. Box 2000, Rahway, N.J. 07065
Merrell-National Laboratories, 2110 East Galbraith Rd., Cincinnati, Ohio 45215 (division of Richardson-Merrell)
Miles Laboratories, P.O. Box 40, Elkhart, Ind. 46515 (owned by Bayer A.G. of West Germany)
Morton-Norwich Products, 110 North Wacker Dr., Chicago, Ill. 60606
Norwich-Eaton Pharmaceuticals, 17 Eaton Ave., Norwich, N.Y. 13815 (division of Morton-Norwich Products)
Organon, 375 Mt. Pleasant Ave., West Orange, N.J. 07052 (division of Akzona)
Ortho Pharmaceutical Corp., Raritan, N.J. 08869 (subsidiary of Johnson & Johnson)
Parke-Davis, P.O. Box 118, G.P.O., Detroit, Mich. 48232 (division of Warner-Lambert Co.)
Pfizer, 235 East 42nd St., New York, N.Y. 10017

Directory

Philips Roxane Laboratories, 330 Oak St., Columbus, Ohio 43216 (division of North American Philips Corp.)

Purdue Frederick Co., 50 Washington St., Norwalk, Conn. 06856

Rachelle Laboratories, 700 Henry Ford Ave., Long Beach, Calif. 90801 (subsidiary of International Rectifier Corp.)

Richardson-Merrell, 10 Westport Rd., Wilton, Conn. 06897

Riker Laboratories, 19901 Nordhoff St., Northridge, Calif. 91324 (subsidiary of 3M Co.)

A.H. Robins Co., 1407 Cummings Dr., Richmond, Va. 23220

Wm. H. Rorer, 500 Virginia Dr., Fort Washington, Pa. 19034 (subsidiary of Rorer Group)

Sandoz Pharmaceuticals, Rte. 10, East Hanover, N.J. 07936 (division of Sandoz of Switzerland)

R. P. Scherer Corp., 9425 Grinnell Ave., Detroit, Mich. 48213

Schering-Plough Corp., Galloping Hill Rd., Kenilworth, N.J. 07033

G. D. Searle & Co., P.O. Box 1045, Skokie, Ill. 60076

SmithKline Corp., 1500 Spring Garden St., Philadelphia, Pa. 19101

Squibb Corp., 40 West 57th St., New York, N.Y. 10019

Sterling Drug, 90 Park Ave., New York, N.Y. 10016

Stuart Pharmaceuticals, 3411 Silverside Rd., Wilmington, Del. 19897 (division of ICI Americas)

Syntex Laboratories, 3401 Hillview Ave., Palo Alto, Calif. 94304

Upjohn Co., 7000 Portage Rd., Kalamazoo, Mich. 49001

USV Laboratories, 1 Scarsdale Rd., Tuckahoe, N.Y. 10707 (division of Revlon)

Wallace Laboratories, Half Acre Rd., Cranbury, N.J. 08512 (division of Carter-Wallace)

Warner-Lambert Co., 201 Tabor Rd., Morris Plains, N.J. 07950

Westwood Pharmaceuticals, 468 Dewitt St., Buffalo, N.Y. 14213 (division of Bristol-Myers Co.)

Winthrop Laboratories, 90 Park Ave., New York, N.Y. 10016 (division of Sterling Drug)

Wyeth Laboratories, P.O. Box 8299, Philadelphia, Pa. 19101 (division of American Home Products Corp.)

Personal-care products

Alberto-Culver Co., 2525 Armitage Ave., Melrose Park, Ill. 60160

Avon Products, 9 West 57th St., New York, N.Y. 10019

Chesebrough-Ponds, 33 Benedict Pl., Greenwich, Conn. 06830

Clairol, 345 Park Ave., New York, N.Y. 10022 (subsidiary of Bristol-Myers Co.)

Colgate-Palmolive Co., 302 Park Ave., New York, N.Y. 10022

Fabergé, 1345 Ave. of the Americas, New York, N.Y. 10019

Max Factor & Co., 1655 McCadden Pl., Hollywood, Calif. 90028 (subsidiary of Norton Simon)

Gillette Co., Prudential Tower Bldg., Boston, Mass. 02199

Andrew Jergens Co., 2535 Spring Grove Ave., Cincinnati, Ohio 45214 (subsidiary of American Brands)

Lever Brothers Co., 390 Park Ave., New York, N.Y. 10022 (owned by Unilever of the U.K.)

Noxell Corp., P.O. Box 1799, Baltimore, Md. 21203

Procter & Gamble Co., P.O. Box 599, Cincinnati, Ohio 45201

Purex Corp., 5101 Clark Ave., Lakewood, Calif. 90712

Revlon, 767 Fifth Ave., New York, N.Y. 10022

Shulton, 697 U.S. Hwy. 46, Clifton, N.J. 07015 (subsidiary of American Cyanamid Co.)

Coatings

Baltimore Paint & Chemical Co., 2325 Hollins Ferry Rd., Baltimore, Md. 21230 (subsidiary of Dutch Boy)

Carboline Co., 350 Hanley Industrial Ct., St. Louis, Mo. 63144

Cook Industrial Coatings, P.O. Box 389, Kansas City, Mo. 64141

DeSoto, 1700 South Mt. Prospect Rd., Des Plaines, Ill. 60018

Dutch Boy, 500 Central Ave., Northfield, Ill. 60093

Glidden Coatings & Resins, 900 Union Commerce Tower, Cleveland, Ohio 44115 (division of SCM Corp.)

Guardsman Chemicals, 1350 Steele Ave., S.W., Grand Rapids, Mich. 49507

Lilly Industrial Coatings, P.O. Box 946, Indianapolis, Ind. 46206

Benjamin Moore & Co., 51 Chestnut Ridge Rd., Montvale, N.J. 07645

O'Brien Corp., 450 East Grand Ave., South San Francisco, Calif. 94080

Porter Paint Co., 13th & Walnut St., Louisville, Ky. 40201

Pratt & Lambert, P.O. Box 22, Buffalo, N.Y. 14240

Sherwin-Williams Co., 101 Prospect Ave., N.W., Cleveland, Ohio 44115

Valspar Corp., 1101 Third St. South, Minneapolis, Minn. 55415

Petroleum

Amerada Hess Corp., 1 Hess Plaza, Woodbridge, N.J. 07095

American Petrofina, P.O. Box 2159, Dallas, Tex. 75221

Ashland Oil, P.O. Box 391, Ashland, Ky. 41101

Atlantic Richfield Co., 515 South Flower St., Los Angeles, Calif. 90071

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Exxon Corp., 1251 Ave. of the Americas, New York, N.Y. 10020
Getty Oil Co., 3810 Wilshire Blvd., Los Angeles, Calif. 90054
Gulf Oil Corp., P.O. Box 1166, Pittsburgh, Pa. 15230
Kerr-McGee Corp., Kerr-McGee Ctr., Oklahoma City, Okla. 73125
Marathon Oil Co., 539 South Main St., Findlay, Ohio 45840
Mobil Oil Corp., 150 East 42nd St., New York, N.Y. 10017
Murphy Oil Corp., 200 Jefferson Ave., El Dorado, Ark. 71730
Occidental Petroleum Corp., 10889 Wilshire Blvd., Los Angeles, Calif. 90024
Pennzoil Co., P.O. Box 2967, Houston, Tex. 77001
Phillips Petroleum Co., Phillips Bldg., Bartlesville, Okla. 74004
Quaker State Oil Refining Corp., P.O. Box 989, Oil City, Pa. 16301
Shell Oil Co., 1 Shell Plaza, Houston, Tex. 77001
Standard Oil Co. of California, 225 Bush St., San Francisco, Calif. 94104
Standard Oil Co. (Ind.), 200 East Randolph Dr., Chicago, Ill. 60601
Standard Oil Co. (Ohio), Midland Bldg., Cleveland, Ohio 44115 (owned 52% by BP Ltd. of England)
Sun Co., 240 Radnor-Chester Rd., St. Davids, Pa. 19087
Tenneco, P.O. Box 2511, Houston, Tex. 77001
Texaco, 2000 Westchester Ave., White Plains, N.Y. 10650
Union Oil Co. of California, 461 South Boylston St., Los Angeles, Calif. 90017

Rubber

American Biltrite, 575 Technology Sq., Cambridge, Mass. 02139
Armstrong Rubber Co., 500 Sargent Dr., New Haven, Conn. 06507
Carlisle Corp., 511 Walnut St., Cincinnati, Ohio 45202
Cooper Tire & Rubber Co., Lima & Western Ave., Findlay, Ohio 45840
Firestone Tire & Rubber Co., 1200 Firestone Pkwy., Akron, Ohio 44317
Gates Rubber Co., 999 South Broadway, Denver, Colo. 80217
General Tire & Rubber Co., 1 General St., Akron, Ohio 44329
B. F. Goodrich Co., 500 South Main St., Akron, Ohio 44318
Goodyear Tire & Rubber Co., 1144 East Market St., Akron, Ohio 44316
Mohawk Rubber Co., 500 Executive Pkwy., Hudson, Ohio 44236
St. Clair Rubber Co., 107 Clifford St., Detroit, Mich. 48226
Uniroyal, Oxford Management & Research Ctr., Middlebury, Conn. 06749

Paper and forest products

Bemis Co., 800 Northstar Ctr., Minneapolis, Minn. 55402
Boise Cascade Corp., P.O. Box 50, Boise, Idaho 83728
Champion International Corp., 1 Landmark Sq., Stamford, Conn. 06921
Consolidated Papers, First Ave. North, Wisconsin Rapids, Wis. 54494
Container Corp. of America, 1 First National Plaza, Chicago, Ill. 60603 (subsidiary of Mobil Oil Corp.)
Continental Forest Industries, Greenwich Office Park 2, Greenwich, Conn. 06830 (member of Continental Group)
Crown Zellerbach Corp., 1 Bush St., San Francisco, Calif. 94104
Diamond International Corp., 733 Third Ave., New York, N.Y. 10017
Georgia-Pacific Corp., 900 South West Fifth Ave., Portland, Ore. 97204
Great Northern Nekoosa Corp., 75 Prospect St., Stamford, Conn. 06901
Hammermill Paper Co., 1442 East Lake Rd., Erie, Pa. 16533
Inland Container Corp., 151 North Delaware St., Indianapolis, Ind. 46206
International Paper Co., P.O. Box 973, Wall St. Station, New York, N.Y. 10005
ITT Rayonier, 1177 Summer St., Stamford, Conn. 06904 (subsidiary of International Telephone & Telegraph Corp.)
Kimberly-Clark Corp., 128 North Lake St., Neenah, Wis. 54956
Mead Corp., Courthouse Plaza, Northeast, Dayton, Ohio 45463
Potlatch Corp., 1 Maritime Plaza, San Francisco, Calif. 94111
Proctor & Gamble Paper Products Co., P.O. Box 866, Oxnard, Calif. 93032
St. Regis Paper Co., P.O. Box 4239, Grand Central Station, New York, N.Y. 10017
Scott Paper Co., Scott Plaza, Philadelphia, Pa. 19113
Union Camp Corp., 1600 Valley Rd., Wayne, N.J. 07470
Westvaco Corp., 299 Park Ave., New York, N.Y. 10017
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Amax, Amax Ctr., Greenwich, Conn. 06830

Anaconda Co., 555—17th St., Denver, Colo. 80271 (subsidiary of Atlantic Richfield Co.)

Armco, P.O. Box 600, Middletown, Ohio 45043

Asarco, 120 Broadway, New York, N.Y. 10005

Basic Chemicals, 845 Hanna Bldg., Cleveland, Ohio 44115 (division of Basic)

Bethlehem Steel Corp., 701 East Third St., Bethlehem, Pa. 18016

Carpenter Technology Corp., 150 West Bern St., Reading, Pa. 19603

Cerro Metal Products, P.O. Box 388, Bellefonte, Pa. 16823 (division of Marmon Group)

Chromalloy American Corp., 120 South Central Ave., St. Louis, Mo. 63105

Climax Molybdenum Co., 1 Greenwich Plaza, Greenwich, Conn. 06830 (division of Amax)

Colt Industries, P.O. Box 226, Midland, Pa. 15059

Copperweld Bimetallics division, 100 Ninth St., Glassport, Pa. 15045 (division of Copperweld Corp.)

Cyclops Corp., 650 Washington Rd., Pittsburgh, Pa. 15228

Duval Corp., P.O. Box 2967, Houston, Tex. 77001 (subsidiary of Pennzoil Co.)

Engelhard Minerals & Chemicals Corp., 1221 Ave. of the Americas, New York, N.Y. 10020

Fansteel, 1 Tantalum Pl., North Chicago, Ill. 60064

Foote Mineral Co., Rte. 100, Exton, Pa. 19341 (owned 90.8% by Newmont Mining Corp.)

Freeport Minerals Co., 200 Park Ave., New York, N.Y. 10017

Gulf Resources & Chemical Corp., 1100 Milam Bldg., Houston, Tex. 77002

Handy & Harman, 850 Third Ave., New York, N.Y. 10022

Howmet Aluminum Corp., 475 Steamboat Rd., Greenwich, Conn. 06830 (affiliate of Pêchiney Ugine Kuhlmann Corp. of France)

Inland Steel Co., 30 West Monroe St., Chicago, Ill. 60603

Interlake, 135th St. & Perry Ave., Chicago, Ill. 60627

International Nickel Co., 1 New York Plaza, New York, N.Y. 10004

Jones & Laughlin Steel Corp., 1000 East Station, Aliquippa, Pa. 15001 (subsidiary of LTV Corp.)

Kaiser Aluminum & Chemical Corp., 300 Lakeside Dr., Oakland, Calif. 94643

Kaiser Steel Corp., 300 Lakeside Dr., Oakland, Calif. 94643 (affiliate of Kaiser Industries Corp.)

Kawecki Berylco Industries, P.O. Box 1462, Reading, Pa. 19603 (subsidiary of Cabot Special Metals Corp.)

Kennametal, P.O. Box 346, Latrobe, Pa. 15650

Kennecott Copper Corp., 161 East 42nd St., New York, N.Y. 10017

Martin Marietta Aluminum, 6801 Rockledge Dr., Bethesda, Md. 20034 (subsidiary of Martin Marietta Corp.)

Matthey Bishop, 4 Malin Rd., Malvern, Pa. 19355 (affiliate of Johnson Matthey & Co. of the U.K.)

McLouth Steel Corp., 300 South Livernois Ave., Detroit, Mich. 48209

Molycorp, 6 Corporate Park Dr., White Plains, N.Y. 10604 (subsidiary of Union Oil Co. of California)

National Steel Corp., 2800 Grant Bldg., Pittsburgh, Pa. 15219

New Jersey Zinc Co., 65 East Elizabeth Ave., Bethlehem, Pa. 18018 (division of Gulf & Western Industries)

Phelps Dodge Refining Corp., 300 Park Ave., New York, N.Y. 10022 (subsidiary of Phelps Dodge Corp.)

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Revere Copper & Brass, 605 Third Ave., New York, N.Y. 10016 (owned 33% by Asarco)

Reynolds Metals Co., P.O. Box 27003, Richmond, Va. 23261

St. Joe Minerals Corp., 250 Park Ave., New York, N.Y. 10017

Teledyne Wah Chang Albany, P.O. Box 460, Albany, Ore. 97321 (subsidiary of Teledyne)

Texasgulf, High Ridge Park, Stamford, Conn: 06904

Titanium Metals Corp. of America, P.O. Box 2824, Pittsburgh, Pa. 15230 (jointly owned by Allegheny Ludlum Industries and NL Industries)

U.S. Steel Corp., 600 Grant St., Pittsburgh, Pa. 15230

Food

American Maize-Products Co., 250 Park Ave., New York, N.Y. 10017

Amstar Corp., 1251 Ave. of the Americas, New York, N.Y. 10020

Anderson Clayton Foods, P.O. Box 6165, Dallas, Tex. 75251 (division of Anderson Clayton & Co.)

Archer Daniels Midland Co., P.O. Box 1470, Decatur, Ill. 62525

Armour & Co., Greyhound Tower, Phoenix, Ariz. 85077 (subsidiary of Greyhound Corp.)

Beatrice Foods Co., 2 North La Salle St., Chicago, Ill. 60602

Borden, 180 East Broad St., Columbus, Ohio 43215

Campbell Soup Co., Campbell Pl., Camden, N.J. 08101

Carnation Co., 5045 Wilshire Blvd., Los Angeles, Calif. 90036

Central Soya Co., 1300 Ft. Wayne National Bank Bldg., Ft. Wayne, Ind. 46802

Consolidated Foods Corp., 135 South La Salle St., Chicago, Ill. 60603

CPC International, International Plaza, Englewood Cliffs, N.J. 07632

Cudahy Co., 100 West Clarendon St., Phoenix, Ariz. 85013 (subsidiary of General Host Corp.)

Del Monte Corp., P.O. Box 3575, San Francisco, Calif. 94119 (subsidiary of R. J. Reynolds Industries)

Esmark, 55 East Monroe St., Chicago, Ill. 60603

General Foods Corp., 250 North St., White Plains, N.Y. 10625

General Mills, P.O. Box 1113, Minneapolis, Minn. 55440

Gerber Products Co., Fremont, Mich. 49412

Heinz U.S.A., P.O. Box 57, Pittsburgh, Pa. 15230

Hershey Foods Corp., 19 East Chocolate Ave., Hershey, Pa. 17033

Geo. A. Hormel & Co., Austin, Minn. 55912

Kellogg Co., 235 Porter St., Battle Creek, Mich. 49016

Kraft, Kraft Ct., Glenview, Ill. 60025

Libby, McNeill & Libby, 200 South Michigan Ave., Chicago, Ill. 60604

Thomas J. Lipton, 800 Sylvan Ave., Englewood Cliffs, N.J. 07632

McCormick & Co., 11350 McCormick Rd., Hunt Valley, Md. 21031

Nabisco, River Rd., East Hanover, N.J. 07936

Norton Simon, 277 Park Ave., New York, N.Y. 10017

Pepperidge Farm, P.O. Box 5500, Norwalk, Conn. 06856 (subsidiary of Campbell Soup Co.)

Pet, 400 South Fourth St., St. Louis, Mo. 63166 (subsidiary of IC Industries)

Pillsbury Co., 608 Second Ave., South, Minneapolis, Minn. 55402

Quaker Oats Co., P.O. Box 3514, Chicago, Ill. 60654

Ralston Purina Co., 835 South Eighth St., St. Louis, Mo. 63188

A. E. Staley Mfg. Co., P.O. Box 151, Decatur, Ill. 62525

Standard Brands, 625 Madison Ave., New York, N.Y. 10022

Stokely-Van Camp, 941 North Meridian St., Indianapolis, Ind. 46206

Swift & Co., 115 West Jackson Blvd., Chicago, Ill. 60604 (subsidiary of Esmark)

Universal Foods Corp., 433 East Michigan St., Milwaukee, Wis. 53202

Wm. Wrigley Jr. Co., 410 North Michigan Ave., Chicago, Ill. 60611

Other manufacturers

Abcor, 850 Main St., Wilmington, Mass. 01887

Aerojet-General Corp., 9100 East Flair Dr., El Monte, Calif. 91734 (subsidiary of General Tire & Rubber Co.)

Allis-Chalmers Corp., P.O. Box 512, Milwaukee, Wis. 53201

Alza Corp., 950 Page Mill Rd., Palo Alto, Calif. 94304

AM Bruning, 1834 Walden Office Sq., Schaumburg, Ill. 60196

American Air Filter Co., 200 Central Ave., Louisville, Ky. 40277

American Brands, 245 Park Ave., New York, N.Y. 10017

American Can Co., American La., Greenwich, Conn. 06830

American Hospital Supply Corp., 1740 Ridge Ave., Evanston, Ill. 60204

American Motors Corp., 14250 Plymouth Rd., Detroit, Mich. 48232

American Optical Corp., 14 Mechanic St., Southbridge, Mass. 01550 (subsidiary of Warner-Lambert Co.)

American Standard, 40 West 40th St., New York, N.Y. 10018

American Telephone & Telegraph Co., 195 Broadway, New York, N.Y. 10007

AMF World Tobacco Group, 6100 Western Pl., Fort Worth, Tex. 76107

AM International, 1900 Ave. of the Stars, Los Angeles, Calif. 90067

AMP, P.O. Box 3608, Harrisburg, Pa. 17105

Ampex Corp., 401 Broadway, Redwood City, Calif. 94063

Anchor Hocking Corp., 70 Glass Ave., Lancaster, Ohio 43130

Anheuser-Busch, 721 Pestalozzi St., St. Louis, Mo. 63118

Armstrong Cork Co., 1010 Concord St., Lancaster, Pa. 17604

Atlantic Research Corp., 5390 Cherokee Ave., Alexandria, Va. 22314

Avco Corp., 1275 King St., Greenwich, Conn. 06830

Babcock & Wilcox Co., P.O. Box 1126, Wall St. Station, New York, N.Y. 10005

Badger Co., 1 Broadway, Cambridge, Mass. 02142 (division of Raytheon Co.)

Baird Corp., 125 Middlesex Tpke., Bedford, Mass. 01730

Bausch & Lomb, 1 Lincoln First Sq., Rochester, N.Y. 14601

Beckman Instruments, 2500 Harbor Blvd., Fullerton, Calif. 92634

Becton, Dickinson & Co., Mack Center Dr., Paramus, N.J. 07652

Becton, Dickinson Immunodiagnostics, Mountain View Ave., Orangeburg, N.Y. 10962

Bell & Howell Co., 7100 McCormick Rd., Chicago, Ill. 60645

Bendix Corp., Bendix Ctr., Southfield, Mich. 48037

Bio-Dynamics, 9115 Hague Rd., Indianapolis, Ind. 46250

Blaw-Knox Equipment, Blaw Ave., Blawnox, Pa. 15238 (division of White Consolidated Industries)

Borg-Warner Corp., 200 South Michigan Ave., Chicago, Ill. 60604

Bostik, Middleton, Mass. 01949 (division of USM Corp.)

Budd Co., 3155 West Big Beaver Rd., Troy, Mich. 48084

Burlington Industries, P.O. Box 21207, Greensboro, N.C. 27420

Burroughs Corp., Burroughs Pl., Detroit, Mich. 48232

Carborundum Co., P.O. Box 337, Niagara Falls, N.Y. 14302 (subsidiary of Kennecott Copper Corp.)

Cargill, Cargill Bldg., Minneapolis, Minn. 55402

Caterpillar Tractor Co., 100 N.E. Adams St., Peoria, Ill. 61629

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Chemical Products Corp., P.O. Box 449, Cartersville, Ga. 30120

Chrysler Corp., P.O. Box 1919, Detroit, Mich. 48288

C&I Girdler, P.O. Box 32940, Louisville, Ky. 40232 (division of Bechtel Corp.)

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Dayco Corp., 333 West First St., Dayton, Ohio 45402

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Dorr-Oliver, 77 Havemeyer La., Stamford, Conn. 06904 (subsidiary of Curtiss-Wright Corp.)

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Eastman Kodak Co., 343 State St., Rochester, N.Y. 14650

El Paso Co., P.O. Box 2185, Houston, Tex. 77001

ESB, 5 Penn Center Plaza, Philadelphia, Pa. 19103

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Fairchild Camera & Instrument Corp., 464 Ellis St., Mountain View, Calif. 94042

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Greyhound Corp., 111 West Clarendon Ave., Phoenix, Ariz. 85077
Grumman Corp., 1111 Stewart Ave., Bethpage, N.Y. 11714
Gulf & Western Industries, 1 Gulf & Western Plaza, New York, N.Y. 10023
G&W Electric Specialty Co., 3500 West 127th St., Blue Island, Ill. 60406
Honeywell, Honeywell Plaza at 27th St., Minneapolis, Minn. 55408
Horizons, 23800 Mercantile Rd., Cleveland, Ohio 44122 (affiliated with Horizons Research)
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Instrumentation Laboratory, 113 Hartwell Ave., Lexington, Mass. 02173
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International Harvester Co., 401 North Michigan Ave., Chicago, Ill. 60611
International Playtex, 888 Seventh Ave., New York, N.Y. 10019 (division of Esmark)
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Itek Corp., 10 Maguire Rd., Lexington, Mass. 02173
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Johnson & Johnson, 501 George St., New Brunswick, N.J. 08903
Johnson Wax, 1521 Howe St., Racine, Wis. 53403
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Litton Industries, 360 North Crescent Dr., Beverly Hills, Calif. 90210
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Loctite Corp., 999 North Mountain Rd., Newington, Conn. 06111
Lorillard, 666 Fifth Ave., New York, N.Y. 10019 (division of Loew's Theatres)
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Lummus Co., 1515 Broad St., Bloomfield, N.J. 07003 (subsidiary of Combustion Engineering)
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Masonite Corp., 29 North Wacker Dr., Chicago, Ill. 60606
McDonnell Douglas Corp., P.O. Box 516, St. Louis, Mo. 63166
McGaw Laboratories, P.O. Box 11887, Santa Ana, Calif. 92711 (division of American Hospital Supply Corp.)
Meloy Laboratories, 6715 Electronics Dr., Springfield, Va. 22151 (subsidiary of Revlon)
Millipore Corp., Wiggins Ave., Bedford, Mass. 01730
Mine Safety Appliances Co., 608 Penn Center Blvd., Pittsburgh, Pa. 15235
Philip Morris, 100 Park Ave., New York, N.Y. 10017
Motorola, 1303 East Algonquin Rd., Schaumburg, Ill. 60196
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Nashua Corp., 44 Franklin St., Nashua, N.H. 03061
National Can Corp., 5959 South Cicero Ave., Chicago, Ill. 60638
National Gypsum Co., 4100 First International Bldg., Dallas, Tex. 75270
NCR Corp., 1700 South Patterson Blvd., Dayton, Ohio 45479
Nicolet, Ford & Washington St., Norristown, Pa. 19401
NL Industries, 111 Broadway, New York, N.Y. 10006
Northern Natural Gas Co., 2223 Dodge St., Omaha, Neb. 68102
Norton Co., 50 New Bond St., Worcester, Mass. 01606
Owens-Corning Fiberglas Corp., Fiberglas Tower, Toledo, Ohio 43659
Owens-Illinois, P.O. Box 1035, Toledo, Ohio 43666
Para-Chem, Ontario & Rorer St., Philadelphia, Pa. 19114
Parkson Corp., 5601 Northeast 14th Ave., Ft. Lauderdale, Fla. 33334 (subsidiary of A. Johnson Co.)
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PCR, P.O. Box 1466, Gainesville, Fla. 32601 (part of organic chemicals division of SCM Corp.)
Perkin-Elmer Corp., Main Ave., Norwalk, Conn. 06856
Petrolite Corp., 100 North Broadway, St. Louis, Mo. 63102
Pierce & Stevens Chemical Corp., 724 Ohio St., Buffalo, N.Y. 14203 (division of Pratt & Lambert)
Polaroid Corp., 549 Technology Sq., Cambridge, Mass. 02139
Polymer Applications, 3443 River Rd., Tonawanda, N.Y. 14150
Polymer Industries, Viaduct Rd., Stamford, Conn. 06907 (subsidiary of Philip Morris)
Pratt & Whitney Aircraft Group, 400 Main St., East Hartford, Conn. 06108 (division of United Technologies Corp.)
Pullman Power Products, P.O. Box 3308, Williamsport, Pa. 17701 (division of Pullman)
Radiation Management Corp., 3508 Market St., Philadelphia, Pa. 19104
Raychem Corp., 300 Constitution Dr., Menlo Park, Calif. 94025
RCA Corp., 30 Rockefeller Plaza, New York, N.Y. 10020
Research-Cottrell, P.O. Box 1500, Somerville, N.J. 08876
R. J. Reynolds Industries, 401 North Main St., Winston-Salem, N.C. 27102
H. H. Robertson Co., 400 Holiday Dr., Pittsburgh, Pa. 15220
Rockwell International Corp., 600 Grant St., Pittsburgh, Pa. 15219
Sargent-Welch Scientific Co., 7300 North Linder Ave., Skokie, Ill. 60077
Jos. Schlitz Brewing Co., 235 West Galena St., Milwaukee, Wis. 53201
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Scientific Design Co., 2 Park Ave., New York, N.Y. 10016 (subsidiary of Halcon International)
SCM Corp., 299 Park Ave., New York, N.Y. 10017
Sears, Roebuck & Co., Sears Tower, Chicago, Ill. 60684
Signal Cos., 9665 Wilshire Blvd., Beverly Hills, Calif. 90212
Singer Co., 30 Rockefeller Plaza, New York, N.Y. 10020
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Sprague Electric Co., 149 Marshall St., North Adams, Mass. 01247 (subsidiary of General Cable Corp.)
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Thiokol Corp., P.O. Box 1000, Newtown, Pa. 18940
U.S. Gypsum Co., 101 South Wacker Dr., Chicago, Ill. 60606
United Technologies Corp., 1 Financial Plaza, Hartford, Conn. 06101
UOP, 10 UOP Plaza, Algonquin Rd., Des Plaines, Ill. 60016 (subsidiary of Signal Cos.)
Varian Associates, 611 Hansen Way, Palo Alto, Calif. 94303
Jim Walter Corp., 1500 North Dale Mabry Hwy., Tampa, Fla. 33622
Western Electric Co., 222 Broadway, New York, N.Y. 10038 (division of American Telephone & Telegraph Co.)
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Will Ross, P.O. Box 2012, Milwaukee, Wis. 53201 (subsidiary of G. D. Searle & Co.)
Xerox Corp., High Ridge Park, Stamford, Conn. 06904
Zenith Radio Corp., 1000 North Milwaukee Ave., Glenview, Ill. 60025

Research

Argonne National Laboratory, 9700 South Cass Ave., Argonne, Ill. 60439
Battelle Columbus Laboratories, 505 King Ave., Columbus, Ohio 43201
Battelle Pacific Northwest Laboratories, P.O. Box 999, Richland, Wash. 99352
Bell Laboratories, 600 Mountain Ave., Murray Hill, N.J. 07974 (division of American Telephone & Telegraph Co.)
Brookhaven National Laboratory, Upton, N.Y. 11973
Carnegie-Mellon Institute of Research, 4400 Fifth Ave., Pittsburgh, Pa. 15213
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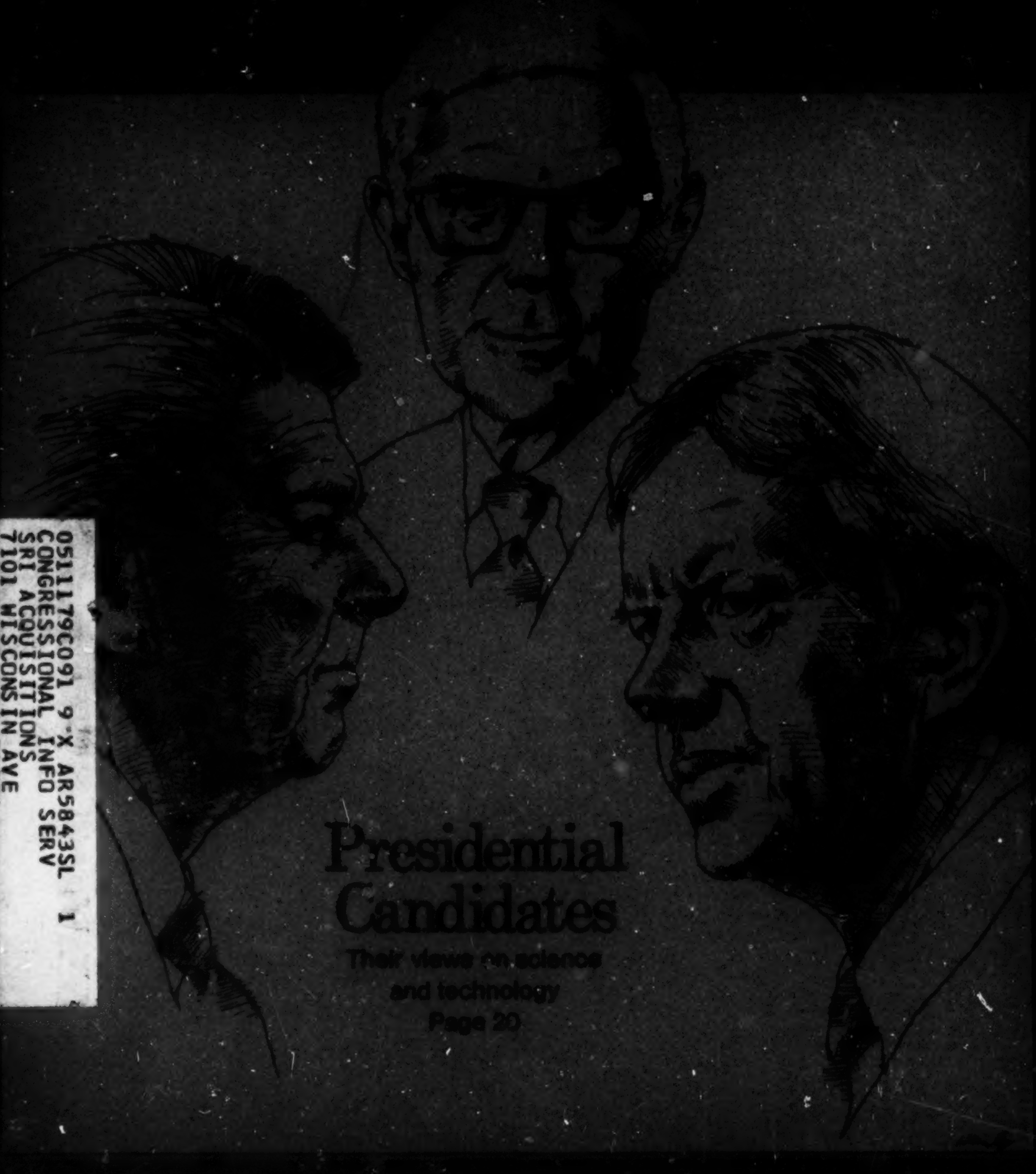
Chemical & Engineering NEWS



Presidential Candidates

Their views on science and technology

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News of the Week

- ***Both earnings and profitability were down*** *in the third quarter at many major chemical companies, but numerous firms see signs of business picking up soon.* ***Page 4***
- ***Week of national debate on nuclear war*** *and nuclear arms issues is being planned, tentatively slated for next April.* ***Page 5***
- ***Genetic engineering field has attracted*** *investment from two big chemical firms: Monsanto has purchased an interest in Biogen, Dow in Collaborative Genetics.* ***Page 5***
- ***Health risk from oral contraceptives*** *appears to be negligible, according to a just-completed, very comprehensive study.* ***Page 6***
- ***Amoco polypropylene plant has exploded,*** *killing five and injuring 23 people; cause of the blast is still unknown.* ***Page 6***
- ***Science and engineering education*** *has declined in quality since the early 1960's, a White House report says.* ***Page 6***

Business

- ***Acrylonitrile-butadiene-styrene plastics*** *have been hit hard by the recession; demand is off sharply, mainly because of downturn in the construction market.* ***Page 13***

International

- ***U.S. foreign chemical investment*** *still totals more and performs better than other countries' growing investment in U.S. chemical industry.* ***Page 17***

Government

- ***Presidential candidates*** *Jimmy Carter, Ronald Reagan, and John Anderson present their views on the many important issues affecting science and technology in responding to questions posed by C&EN.* ***Page 20***

Science

- ***National Resource for Computation in Chemistry*** *will end operations because of cutoff in funding prompted by critical review of its three-year performance.* ***Page 29***
- ***Nearly 8000 scientists from 44 countries*** *have pledged to suspend scientific cooperation with the U.S.S.R. because of treatment of dissident Soviet scientists.* ***Page 30***

Technology

- ***Processes to make ammonia from coal,*** *several new fertilizers were detailed by Tennessee Valley Authority at its biennial show.* ***Page 32***

ACS News

- ***Stephen D. Ziman and David L. Eck*** *complete year as 1979-80 ACS Congressional Fellows; each believes he was able to contribute to the policy process.* ***Page 34***
- ***Regional Employment Clearing House*** *will be operated by ACS at the 12th Central Regional Meeting in Pittsburgh.* ***Page 35***
- ***Official reports*** *of board and council actions at the congress in Las Vegas.* ***Page 36***

CHEMICAL EARNINGS DROP IN THIRD QUARTER

Net earnings as well as profit margins at many of the major chemical companies fell in the third quarter—in some cases dramatically.

For 25 companies surveyed by C&EN thus far, earnings excluding nonrecurring items in the third quarter have fallen an average of 16.5% from the third quarter last year. Profit margins have dropped to an average 5.0% from last year's 6.4%.

For the first nine months of 1980, things are not much brighter. The drop in net profits for the 25 companies in the third quarter as well as the second has been enough to offset the rise in earnings in the first quarter. Thus, nine-month earnings have dropped 0.6% from last year's levels. Profit margins have fallen to 6.1% from 6.8% achieved in the first three quarters of 1979.

The drop in third-quarter earnings was not universal, but companies with lower performances far outnumbered those whose earnings improved. Of the 25 companies surveyed so far, profits dropped for 15 of them in the quarter. And, somewhat surprisingly, earnings of 14 companies were lower for the first nine months than in the comparable 1979 period.

The reasons for the earnings drop were basically the same as in the second quarter—a decrease in volumes and inability to make up increased costs.

For instance, Stauffer Chemical says that its domestic volume in the quarter was off 13% from a year ago. Dow Chemical says that most of its 19% earnings decline was caused by lower unit sales volume. Profits at Dow also were affected by softening of selling prices as many costs continued to increase. Du Pont says that its physical volume in the U.S. was off 14% from a year ago. As a result, Du Pont's U.S. earnings fell to 42 cents a share in the third quarter from 99 cents a share in the same period last year.

A new worry has now begun haunting U.S. companies—the prospect of slower international business. Although most companies say that business is holding up in Latin America and the Far East, some say that European business has begun to feel its own slowdown.

Du Pont says that its international results are mixed. International sales in the third quarter increased 8%, but volumes were off 6% from a year ago. Du Pont's business in Latin America, and particularly in Brazil, and U.S. exports to the Asia/Pacific region remained strong. But European business was weak.

G. J. Williams, Dow's financial vice president, says that that company's "business activity in Europe declined

Profitability falls for most companies on earnings drops

$ Millions	Third-quarter 1980 Sales	Change from 1979	Earnings[a]	Change from 1979	Profit margin[b] 1980	Profit margin[b] 1979	Nine-months 1980 Sales	Change from 1979	Earnings[a]	Change from 1979	Profit margin[b] 1980	Profit margin[b] 1979
Air Products	$ 369.3	6.2%	$23.3	−11.1%	6.3%	7.5%	$ 1,104.2	15.7%	$ 64.4	11.6%	7.6%	7.9%
Akzona	237.2	−0.8	−3.9	c	c	1.8	774.8	5.2	2.0	−89.5	0.3	2.6
Allied Chemical	1323.0	5.8	66.2	244.8	5.0	1.5	4,071.0	34.2	207.5	91.8	5.1	3.6
American Cyanamid	869.2	11.2	48.3	35.3	5.6	4.6	2,536.2	8.8	119.2	−0.3	4.7	5.1
Celanese	785.0	0.9	21.0	−43.2	2.7	4.8	2,435.0	4.4	82	−28.1	3.4	4.9
Diamond Shamrock[d]	773.2	27.5	42.6	15.1	5.5	6.1	2,297.6	36.3	155.3	29.8	6.8	7.1
Dow Chemical	2521.3	3.9	160.5	−19.1	6.4	8.2	7,853.5	15.4	562.2	−4.6	7.2	8.7
Du Pont	3109.7	1.2	98.1	−58.1	3.1	7.5	10,149.9	8.0	519.1	−27.4	5.1	7.6
Essex Chemical	42.1	23.5	1.1	−32.7	2.5	4.6	113.0	19.1	3.1	−27.2	2.6	4.5
Ethyl Corp.	429.9	−2.7	19.2	−31.8	4.5	6.3	1,309.0	6.8	64.5	−14.6	4.9	6.2
First Mississippi	57.6	30.6	3.8	65.2	6.6	5.2	194.8	29.2	17.1	83.9	8.8	6.2
Freeport Minerals	181.5	40.2	37.4	34.5	20.6	21.5	485.5	35.6	102.6	39.8	21.1	20.5
W. R. Grace	148.7	15.1	64.3	41.9	4.3	3.5	4,392.5	15.1	212.3	30.4	4.8	4.3
Hercules	582.0	−3.8	27.9	−33.3	4.8	6.9	1,852.0	5.9	88.5	−25.1	4.8	6.8
International Minerals	462.8	19.6	44.3	30.3	9.6	8.8	1,421.6	16.6	127.2	29.9	8.9	8.2
Monsanto	1538.7	2.8	29.8	−70.1	1.9	6.6	4,909.8	5.6	217.0	−32.2	4.4	6.9
Olin	429.1	0.2	12.1	1.7	2.8	2.8	1,387.8	[illegible]	61.4	8.3	4.4	4.2
Pennwalt	292.1	9.6	9.0	−22.0	3.1	4.3	887.3	11.5	32.2	15.5	3.6	4.8
PPG Industries	765.3	−2.4	47.8	−15.1	6.2	7.2	2,320.0	1.3	142.2	−13.2	6.1	7.2
Reichold Chemicals	214.0	−3.3	4.7	275.0	2.2	0.6	663.5	1.7	9.1	−6.2	1.4	1.5
Rohm & Haas	403.9	3.0	22.6	−13.9	5.6	6.7	1,306.7	8.7	76.7	−0.8	5.9	6.4
Stauffer Chemical	329.8	5.5	4.5	−65.1	1.4	4.1	1,269.8	9.8	94.1	−5.9	7.4	8.6
Texasgulf	285.7	49.3	68.9	96.2	24.1	18.3	806.3	41.7	244.6	163.9	30.3	163
Thiokol	170.6	27.0	6.6	−25.0	3.9	6.6	476.7	15.2	23.9	−1.6	5.0	5.8
Union Carbide	2363.7	2.5	153.8	−13.6	6.5	7.7	7,320.2	9.0	523.6	2.5	7.2	7.5

a After-tax, before major extraordinary or nonrecurring items, for continuing operations. b After-tax income as a percentage of sales. c Deficit. d Earnings exclude major extraordinary or nonrecurring items.

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during the quarter. Dow plant operations were reduced correspondingly to minimize inventory buildup."

The one bright spot for chemical companies in the third quarter seems to be an apparent turnaround in fibers activity, which has been depressed for some time. However, this apparent upswing did not affect all fiber producers. Monsanto, Du Pont, and Akzona all suffered earnings declines in their fibers operations. But Celanese's fibers earnings increased 36% in the quarter, and Allied Chemical's operating profits from its fibers operations improved.

The common thread that is running through most of the earnings reports is a hope that the third quarter represented a bottom to the economic slowdown. This was voiced by a number of companies in a number of ways, but in general the tone was that business had either picked up in the late part of the quarter or that there were signs that it would be picking up soon. □

Public debate of nuclear arms planned

A week of nationwide debate and study that will do for public awareness of the issue of nuclear war what "Earth Day" did in 1970 for such awareness of environmental matters is the goal of an ad hoc group now in the throes of getting organized.

Dubbed "Ground Zero," the proposed organization perceives itself as a coalition of other groups. It is planned around the belief that an educated and involved public is critical to dealing with nuclear war and nuclear arms issues. The week of discussion is tentatively scheduled for April 19 to 26, 1981. Under present plans, the organization itself will go out of existence immediately afterward.

An initial meeting in Washington, D.C., last week to elicit interest in the group was attended by representatives and observers from professional, educational, religious, labor, and scientific organizations. Included were the American Chemical Society, American Association for the Advancement of Science, and National Education Association. There was strong agreement that for about the past 15 years the public has shied away from active concern about nuclear war, considering it to be either unthinkable or beyond comprehension. There also was consensus that this attitude can be changed with a concerted educational effort.

At this stage organizers of Ground Zero are seeking commitments from scientific and other groups for funding, staff support, office space, or other help. They also seek to encourage other organizations to develop their own programs.

Early plans for the week of national debate are elaborate. They call for town meetings, religious activities, programs in the arts, projects at schools and universities, and involvement of the news media. The idea is to center all activity around three questions—How could a nuclear war start? What would be the consequences of nuclear war? How can nuclear war be prevented?

At the Washington meeting, keynote speaker William Colby brought home the immediacy of the nuclear threat. He stressed that nuclear war is neither theoretical, fictional, nor "something out of Dr. Strangelove." He said it is a "hard possibility." The former director of the Central Intelligence Agency pointed out that the targeting doctrines of both the U.S. and the Soviet Union are based on selective use of strategic nuclear weapons. He also explained that national policy for stopping a Soviet invasion of Western Europe calls for use of tactical nuclear weapons.

Although the tenor of the meeting last week was generally supportive of the Ground Zero concept, two critical issues were raised. Could such an ambitious effort be mounted effectively by next April? And how could the third question—How can nuclear war be prevented?—be handled on a purely educational basis, without becoming divisive? □

Monsanto, Dow invest in genetic engineering

Sponsorship by the chemical and related industries is becoming more and more prominent in the meteoric growth of genetic engineering (recombinant DNA) enterprises. Most recently, Monsanto and Dow Chemical have made major investments in this field.

Monsanto has purchased $20 million worth of preferred stock of Biogen N.V., a major developer of genetic engineering based in the Netherlands Antilles with laboratories in Geneva, Switzerland. And Dow has invested more than $5 million in Collaborative Genetics Inc., an independent firm located in Waltham, Mass.

These two moves add to earlier investments in gene splicing work of independent firms by Hoffman-La Roche, Eli Lilly, Schering-Plough, Bristol-Myers, Lubizol, Inco, Koppers, National Distillers, Standard Oil of California, Standard Oil (Ind.), National Patent Development Corp., and Monsanto.

Fernandez: attractive opportunity

As part of Monsanto's purchase of Biogen stock, Monsanto vice chairman Louis Fernandez will join Biogen's board of supervisory directors. Fernandez comments, "Monsanto views its investment in Biogen as an attractive business opportunity consistent with its commitment to become an effective user of recombinant DNA techniques."

Biogen, whose work is aimed primarily at medical applications, says that Monsanto's investment continues Biogen's policy of financing through investment by a small number of leading corporations with businesses in likely application areas of recombinant DNA technology. Biogen has not disclosed what share of ownership Monsanto's purchase represents. Hence, it presently will not go the route of San Francisco-based Genentech, another gene splicing developer that went public a week earlier with a stock issue, causing a sensation on Wall Street.

ACS election reminder

Ballots for president-elect and for regional directors (Regions II and IV) were posted in Washington, D.C., on Oct. 3. Ballots were sent by third-class mail to members in the continental U.S. (except Alaska) and by first-class or air mail to all others. To be counted, ballots must be received at ACS headquarters on or before Monday, Nov. 17, 1980. Any member who has not received the ballot mailing by Nov. 3 should contact Rodney N. Hader, secretary of the society, at (202) 872-4461; replacement ballots will be sent by first-class mail.

Committee on Nominations & Elections

U.S. foreign chemical investment still strong

Despite growth of foreign investment in U.S. chemical industry, U.S. firms' foreign chemical investments still total more, perform better

The old fear in many parts of the world of increasing U.S. control of foreign chemical industries has changed to fear in the U.S. of the same thing happening in reverse.

Indeed, one of the outstanding trends of the 1970's was the greatly increased flow of the world's chemical investment funds into the U.S. because of newly perceived advantages in U.S. raw material costs, labor costs, political stability, and other background conditions.

But in spite of the big foreign takeover announcements, not that much has really changed. True, fresh chemical investment into the U.S. from outside is now slightly ahead of U.S. chemical investment in other countries. However, gross investment and earnings by U.S. chemical interests in other countries still far exceed investment and earnings of foreign chemical interests in the U.S. And foreign-owned chemical operations in the U.S. are still a small part of the total industry.

That's the picture emerging from the mass of statistics released by the Commerce Department, filling out earlier, more general conclusions (C&EN, Sept. 8, page 6). These numbers yield some interesting insights.

On one hand, foreign investment in the U.S. is certainly strong. New investment in U.S. chemicals and allied products from foreign countries at $743 million in 1979 was more than the $715 million invested by U.S. chemicals and allied products companies outside the U.S. And the 35% chemical share of total foreign investment in U.S. manufacturing is greater than the 24% chemical share of total U.S. manufacturing investment abroad.

However, for sheer size and earnings power, foreign chemical investment in the U.S. has a long way to go to equal U.S. investment abroad. Gross foreign investment in U.S. chemicals and allied products of $7.1 billion at the end of 1979 was just 37% of the $19 billion of U.S. investment in foreign chemical enterprises. Also, after-tax earnings of foreign-owned U.S. chemical affiliates of $430 million ran way behind the $3.3 billion in earnings of U.S.-owned chemical affiliates in other countries. The same sort of comparison is true for reinvested earnings and royalty payments.

By gross "investment," Commerce means the net book value of U.S. direct investors' equity (stock) in and outstanding loans to foreign affiliates in which a single U.S. investor owns at least 10% of voting securities. The current investment flows are new equity and account outflows (loans) for the latest year. Earnings include income from both incorporated and unincorporated affiliates, with all correction for interest and taxes on dividends.

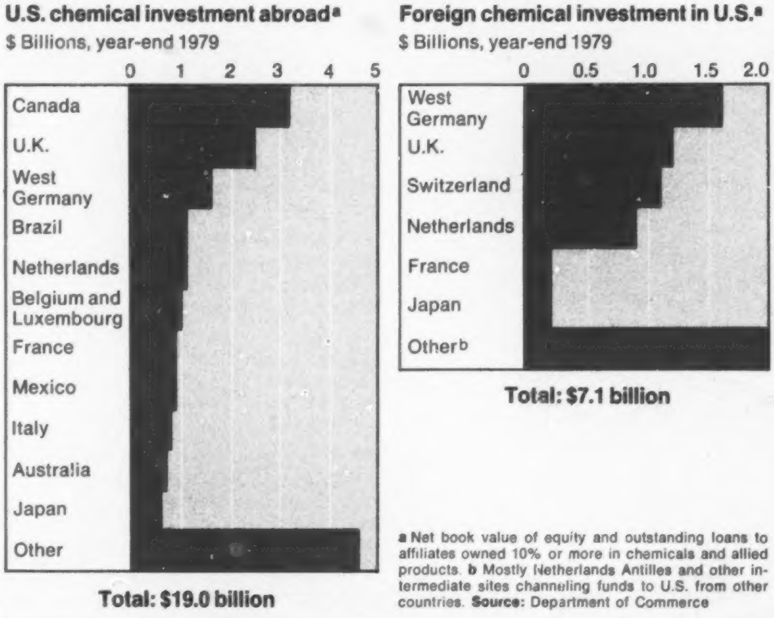
The current growth of U.S. chemical investment abroad, at 18% last year, is also greater than the 16% growth of foreign chemical investment in the U.S. despite the smaller amount of such foreign holdings in the U.S. In earnings, a 58% jump for U.S. interests abroad in 1979 far exceeded a 13% increase in foreigners' U.S. chemical income.

In other measures, reinvested earnings in incorporated affiliates rose [illegible]8% at foreign chemical operations of U.S. chemical owners, compared to 27% at U.S. chemical units owned from abroad.

Only in new chemical investment is the trend running relatively stronger toward the U.S. than away from it. Foreign owners cut 6% from new equity and loans in the U.S. in 1979, whereas U.S. investors slashed 27% from their new equity and loans abroad. However, this source of funds is small compared to reinvested earnings in total investment.

Another striking overall difference in chemical investment flows in and out of the U.S. is the number of major countries involved each way. U.S. investment abroad is much more dispersed than are leading sources of investment in the U.S.

Countries receiving chemical investment from U.S. are more diverse than countries investing in U.S.



Total: $19.0 billion

[a] Net book value of equity and outstanding loans to affiliates owned 10% or more in chemicals and allied products. [b] Mostly Netherlands Antilles and other intermediate sites channeling funds to U.S. from other countries. **Source:** Department of Commerce

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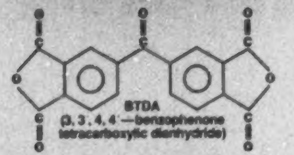

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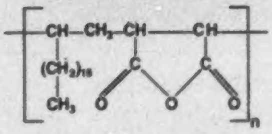

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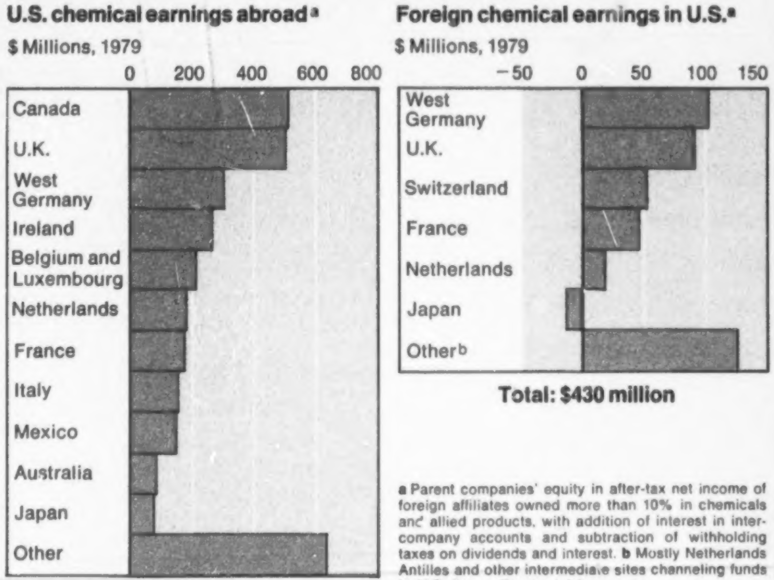
Earnings of U.S. chemical companies abroad dwarf earnings of foreign chemical companies in U.S.



Total: $3.28 billion

Total: $430 million

[a] Parent companies' equity in after-tax net income of foreign affiliates owned more than 10% in chemicals and allied products, with addition of interest in intercompany accounts and subtraction of withholding taxes on dividends and interest. [b] Mostly Netherlands Antilles and other intermediate sites channeling funds to U.S. from other countries.
Source: Department of Commerce

The $19 billion in total U.S. chemical investment abroad is spread among a dozen major recipient countries and many smaller ones. And investment is growing 10% or more in all regions of the world. In the billion-dollar category are Canada with $3.2 billion, the U.K. with $2.5 billion, West Germany with $1.6 billion, Brazil with $1.1 billion, the Netherlands with $1.1 billion, and Belgium and Luxembourg with $1.0 billion combined at the end of 1979.

By region, Europe is by far the largest with 51% of total U.S. chemical investment abroad. Next are Latin America with 19% and Canada with 17%. All other areas are small, including Japan with just 3%.

From the other direction, gross chemical investment in the U.S. comes very largely from a few European countries. Tops in direct funding is West Germany with $1.6 billion, followed by the U.K. with $1.2 billion, Switzerland with $1.1 billion, and the Netherlands with $900 million. Other direct sources are much smaller, notably France and Japan at $200 million apiece. Fully 74% of direct chemical investment in the U.S. comes from Europe.

With foreign chemical investment in the U.S., there is a considerable presence of indirect funds through tropical way stations such as the Netherlands Antilles and the Bahamas. This route accounted for $1.5 billion in foreign ownership of U.S. chemical operations at the end of 1979, up from $1.2 billion the year before. Such a path as yet plays no important role in U.S. chemical investment abroad.

In earnings from chemical investments abroad, the Europe-U.S. tie is also quite prominent. For U.S. investment abroad, 60% of earnings come from Europe. This source zoomed up 76% in 1979 over 1978.

In the reverse investment direction, European chemical investments in the U.S. made 73% of all chemical earnings by direct foreign investors. Probably even more than this went to Europe, since the intermediary owners in the Caribbean and other areas made another 27% of these earnings.

In perspective, these earnings by foreign chemical investors in the U.S. equaled about 4% of 1979 earnings of U.S. chemicals and allied products companies measured by the Federal Trade Commission. Earnings of U.S.-owned chemical operations abroad equaled 30% of the FTC's earnings total.

In terms of investment, the foreigners' total in the U.S. at the end of 1979 was about 7% of the comparable total of equity and debt measured by FTC for U.S. chemicals and allied products companies. U.S. companies' investment in non-U.S. chemical operations ran about 19% of this total.

Obviously, the foreign chemical presence in the U.S. is substantial and growing. But U.S. chemical companies are holding up their end quite well in the international investment exchange.

William Fallwell, New York